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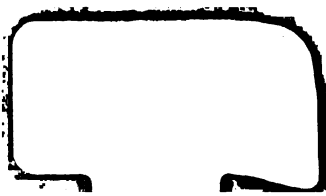
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**THIRTY-FIRST ANNUAL REPORT**

OF

**THE LOCAL GOVERNMENT BOARD,  
1901-02.**

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**SUPPLEMENT**

IN CONTINUATION OF THE

**REPORT OF THE MEDICAL OFFICER**

**For 1901-02.**

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**ON LEAD-POISONING AND WATER  
SUPPLIES:—VOL. II.**

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*Presented to both Houses of Parliament by Command of His Majesty.*

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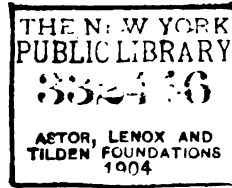
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MICHIGAN

**PUBLIC HEALTH.**

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**PAPERS**

**ON**

**LEAD-POISONING AND WATER  
SUPPLIES,**

**SUBMITTED BY THE**

**MEDICAL OFFICER**

**OF**

**THE LOCAL GOVERNMENT BOARD.**

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**REPORT BY Dr. HOUSTON ON MOORLAND  
WATERS IN REGARD  
OF THEIR ACTION ON LEAD,  
Vol. II.**

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# REPORT.

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TO THE RIGHT HONOURABLE WALTER HUME LONG, M.P.,  
PRESIDENT OF THE LOCAL GOVERNMENT BOARD.

SIR,

IN my introduction to the Report by Dr. Houston, on Moorland Waters in regard of their action on lead, which was issued last year,\* I pointed out that Dr. Houston's conclusions on the whole subject of his inquiry had been determined, in part by the results of his systematic study of waters derived from a variety of moorland gathering grounds in Lancashire and Yorkshire, and in part by the results obtained from a prolonged and extensive series of laboratory experiments. The former were fully recorded in last year's volume; the latter are set out in the volume now submitted.

The detailed observations here placed on record afford abundant evidence of the thoroughness with which the inquiry was pursued, and of the care which Dr. Houston has taken at each stage of his investigations to assure himself of the facts. In addition, they form valuable material for reference when—measures in prevention of lead poisoning being in contemplation—difficulty arises in interpreting the results obtained by examination of a moorland water, or in determining in a given instance the chemical and biological factors concerned in producing acidity, ability to dissolve lead, or ability to "erode" lead pipes. The classification of subjects and the arrangement of tables which Dr. Houston has adopted will facilitate reference for this purpose.

I may add that due account was taken of the data now published in preparing the introduction to last year's volume, in which I dealt with the practical bearings of the whole inquiry, and with the considerations as to the prevention of lead poisoning which should be kept in mind by those responsible for the management of water supplies derived from moorland sources. Here it is only necessary to add that Dr. Houston's observations in Addendum B. of this volume (p. 443) on the question of "Standards" promise to be of considerable practical utility. In this Addendum he indicates the tests which he has

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\* Thirtieth Annual Report of the Local Government Board. Supplement (in continuation of the Report of the Medical Officer) on Lead Poisoning and Water Supplies. [Cd. 1343.]



found capable of uniformly detecting certain degrees of acidity, of ability to dissolve lead, and of ability to "erode" lead, which should without question be regarded as rendering a water unsuited for supply through lead pipes.

I have the honour to be,

Sir,

Your obedient servant,

W. H. POWER.

November, 1903.

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\* Report of the Medical Officer, Local Government Board, 1893–4. Lead-Poisoning by Moorland Waters. By W. H. Power, F.R.S.

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## DR. HOUSTON'S REPORT.

### INTRODUCTORY.

In 1887, Mr. W. H. Power, after study of the subject of lead poisoning by moorland waters generally, and of the facts recorded respecting the particular case of Sheffield, wrote as follows:—\*

"Phenomena such as these, if observed in the biological laboratory in relation with the life processes of one or another microphyte, would not be difficult of comprehension." The suggestion of them, therefore, in this connexion will have raised suspicion whether the inscrutable behaviour of soft moorland waters in regard of their plumbo-solvent ability may not be related to the agency, direct or indirect, of low forms of organic life. So that the question would seem to be arising whether chemistry, which by itself has failed to afford satisfactory explanation of the plumbo-solvency of moorland waters, may not get advantage by association of biology in the problem."

"In 1890 the sanction of the Board was obtained to an inquiry into this subject by the Medical Department, such inquiry to include not only chemical and bacteriological study of the circumstances which might give to these waters the power of dissolving lead, but also simultaneous investigation at the various gathering grounds of the origin and characters of the waters having plumbo-solvent quality."†

In 1893, Mr. W. H. Power gave an account of the progress of this inquiry; of the provisional conclusions that had been arrived at; and of the several lines of work that were being followed up by the experts engaged in the investigation.‡

Last year (1902) Volume I. of the detailed report was issued. The present volume (Volume II.) completes the record of the prolonged investigations carried out during the inquiry. Subjoined are notes of previous official publications on the subject:—

The Sheffield outbreak of plumbism in 1885, very ably reported on by Dr. Sinclair White, the Medical Officer of Health of that borough.

Observations on the general subject of lead poisoning by moorland waters, with special reference to the Sheffield Epidemic, by Mr. W. H. Power, in 1887.

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\* Supplement by the Medical Officer to the 17th Annual Report of the Local Government Board.

† Quotation from the late Sir Richard Thorne Thorne's introduction to Mr. W. H. Power's interim report (App. A., No. 13, Report of the Medical Officer, Local Government Board, 1893-94).

‡ Lead Poisoning by Moorland Waters. By Mr. W. H. Power, F.R.S. App. A. No. 13, Report of the Medical Officer, Local Government Board, 1893-94.

**Records of Water Supplies in the Sanitary Districts of the West Riding of Yorkshire, collected as introductory to an investigation by the Medical Department, of the local conditions affecting the Solubility of Lead by Water; by the late Dr. Barry, in 1891.**

**Like records for the Counties of Lancaster, Cumberland, and Westmoreland; by the late Mr. T. W. Thompson in 1892.**

**Interim report by Mr. W. H. Power, in 1893, on the progress of the inquiry undertaken by the Medical Department of the Local Government Board in 1890.**

**Volume I. of the detailed report was issued in 1902.**

**It will be convenient for purposes of reference to give in the following pages a brief summary of the matters which have been dealt with in Volume I.**

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## SUMMARY OF VOL. I.

### Part I. — Differential Examination, at weekly intervals and over a long period, of waters of diverse sort from one and the same moorland gathering ground.

The object of this branch of the inquiry was to submit severally to frequent comparative tests waters which, when combined together at a distance from their common *moorland* gathering ground, constitute a public water supply. This with a view to determine—

- (a.) What are the seasonal modifications of each of such contributory waters.
- (b.) In what way and to what degree they differ at one and another time from each other as regards their constituents.
- (c.) How far diversity of their ability to dissolve lead is associated with season of the year, and is at the same time parallel to observed differences in their chemical and bacterial characters.

A gathering ground of the sort desired was selected at Burnmoor, in the neighbourhood of Settle, in the West Riding of Yorkshire.

On the Burnmoor gathering ground it was found that the contributory waters of which I have spoken were of two kinds, and this observation has since been amply confirmed on diverse moorland gathering grounds:—

- (a.) Acid peaty water, possessed of plumbo-solvent ability.
- (b.) Neutral, and often alkaline (in the sense of being able to correct acidity), spring water, devoid of plumbo-solvent ability.

With a view to subjecting waters of this type to detailed scrutiny, and to determine the factors which govern the acquisition of plumbo-solvency, the following waters upon the Burnmoor (Bentham) gathering ground were chosen for examination:—

- (a.) The waters of certain *springs* representing rain which, falling on the gathering ground, had escaped prolonged contact with the peat soil, and had been chemically modified in passage through or between strata underlying the peat. As representative of (a) class of waters, two springs were selected, respectively termed in this report—

Bentham (Burnmoor) Spring No. 1.

No. 2.

(In the course of the investigation it was ascertained that Spring No. 1 (and in lesser degree Spring No. 2) was subject to occasional contamination with surface peaty water. The results as regards Spring No. 1 will not therefore be included in this summary.)

- (b.) The waters of certain *pools* representing rain-water that had remained in sustained contact with peat or moss and with living or dead vegetable matter. As typical of (b) class of waters, two waters were chosen, namely:—

Bentham (Burnmoor) Peat Pool.

Moss Pool.

- (c.) The water of the stream descending towards the service reservoirs, and which represented mixture, differing in proportion from time to time, of waters of the class (a) and (b). As typical of the (c) class of water a stream was selected, namely:—

Bentham (Burnmoor) Bright Syke Stream.

The following is a résumé of the chief results of the chemical analyses of these waters, carried out at weekly intervals over a prolonged period:—

**CHEMICAL EXAMINATION of the several selected BURNMOOR WATERS.**  
(Average results stated as parts per 100,000.)

Chemical Composition as regards	Bentham Spring No. 2. Nov. 9, 1891, to March 27, 1893.	Bentham Peat Pool. Nov. 9, 1891, to March 27, 1893.	Bentham Moss Pool. Nov. 9, 1891, to March 27, 1893.	Bentham Bright Syke Stream. March 28, 1892, to March 27, 1893.
Total solids - -	5.5	7.0	6.5	5.0
Free ammonia - -	0.006	0.005	0.005	0.005
Albuminoid ammonia -	0.02	0.06	0.065	0.014
Oxidised nitrogen -	0.025	0.03	0.028	0.023
Oxygen absorbed from permanganate.	0.3	1.8	1.7	0.33
Chlorine - - -	0.9	0.9	0.92	0.9
Hardness - - -	3.0	2.8	3.0	3.0
Dissolved oxygen -	1.02	1.04	0.96	1.2

Although on an average these waters did not differ from each other to any notable extent as regards their chemical constituents,\* they nevertheless showed, in respect of their action on lead and their reaction, the most striking points of distinction. These facts may be emphasised in the following manner:—

Reaction and Plumbo- solvency.	Waters representative of <i>Moorland Springs and Streams</i> (Mixture in variable proportion of Spring and Peaty Waters). Bentham Springs and Bright Syke Stream.	Waters representative of <i>Moorland Peaty Water</i> unmixed (or almost so) with Spring Water. Bentham Peat and Moss Pools.
Neutral waters and waters apt to be possessed as well of an appreciable amount of acid neutral- ising ability.	+	—
Waters yielding an acid reaction and containing a measurable quantity of acid.	—	+
Waters practically free from any solvent action on lead.	+	—
Waters possessed of strong plumbo-solvent ability.	—	+

\* The peaty waters, of course, gave the highest results as regards organic matter.

As the result of the Burnmoor investigations the following conclusions were put forward :—

- (1.) At Burnmoor the chemical composition of spring water, peaty water, and moorland spring (mixed) water, was very similar in respect of total solids, organic matter, oxidised nitrogen, chlorine, hardness, and dissolved oxygen, although peaty water gave the highest results as regards organic matter.
- (2.) In the course of a series of examinations of spring water, peaty water, and moorland stream water, carried over many months, it was found that variations in chemical composition in respect of total solids, organic matter, oxidised nitrogen, chlorine, hardness, and dissolved oxygen were in no case accompanied by corresponding variations in plumbo-solvent ability.
- (3.) In respect of acidity, however, there was in general a marked contrast between the several waters, which corresponded to observed differences between them in lead-dissolving property. Moreover, in the course of a long series of examinations carried over many months it was found that in the case of a given water variations in acidity were accompanied by corresponding variations in plumbo-solvent ability. And from these observations, since confirmed on a plurality of gathering grounds, it may be affirmed that in general—
- (4.) Moorland spring water is, practically speaking, neutral and free from plumbo-solvent ability. Commonly it is possessed as well of a slight but still an appreciable degree of acid-neutralising ability.
- (5.) Moorland peaty water is usually distinctly acid and possessed of a vigorous solvent action on lead.
- (6.) Moorland streams (mixture of spring and peaty water) are either neutral and free from plumbo-solvency, or acid, and possessed of plumbo-solvent ability.

The ability to dissolve lead of a given moorland water of mixed origin, such as a stream fed partly from springs and partly by surface and peaty water, depends upon the degree of the acidity possessed by its acid constituent waters, upon the volume of these acid constituent waters relative to the total bulk of mixed water, and upon the volume of the constituent waters which possess ability to neutralise acid. Here I may observe that laboratory experiments have shown conclusively that an acid peaty water may be deprived of its acidity and plumbo-solvency by admixture with moorland spring water possessed of acid neutralising ability. Given a continuance of favourable counter-balancing conditions, a mixed water which constantly receives a proportion of highly acid water may nevertheless remain without ability to act upon lead.

During 1893 a further series of experiments was carried out at Burnmoor.

These comprised the chemical analyses, on lines broadly parallel with the previous investigations, of the water of Bentham Reservoir. The samples of water were collected both from near the surface and near the foot of the water in the reservoir. These observations were made because the Burnmoor supply to Bentham village was reputed to act occasionally vigorously on lead, and to have caused lead poisoning in the past. During the prolonged investigations carried out at Burnmoor it was found that a tributary to this reservoir, Bright Syke



stream, did not become acid and possessed of plumbo-solvent ability, although certain of the contributory waters (Peat and Moss Pools) were strongly acid, and acted on lead to a conspicuous extent. Bright Syke is not, however, the only source of supply of Bentham Reservoir, and, in the circumstances, it was considered advisable to ascertain whether this reservoir water did, as a matter of fact, occasionally acquire plumbo-solvent ability. For this purpose it was decided to subject to weekly chemical tests the sum of the waters collected from the Burnmoor gathering ground and stored in the reservoir; and it was decided to collect the samples both from near the surface and also from near the foot of the reservoir.

In summarising the results obtained the following points are worthy of note:—

The samples of water obtained from near the foot of the reservoir and those collected from near the surface did not differ the one from the other to any notable extent in their chemical composition. And although they were less "soft," and contained more solids, they did not seem to differ much in other respects from the waters which have been considered in detail in the earlier part of this report. As regards reaction and action on lead, both sets of samples were found to be invariably neutral and free from plumbo-solvency.

Samples were collected for detailed examination at weekly intervals from August 4th to December 27th, 1893, both dates inclusive. Samples were also collected on 39 other occasions during September, October, and November 1893, and these were tested for their reaction. The water, however, was always found to be neutral.

During the whole period of observation, therefore, the water of Bentham Reservoir was proved to have no solvent action upon lead. The result was not altogether what had been anticipated, in view of the general statements which had been made before 1893 as to the lead-dissolving properties possessed by this water, and for the purposes of this inquiry it is rather a matter for regret that it did not become plumbo-solvent during the period of observation. The results obtained, however, are not without value in their negative aspects. They furnish a good example of a moorland water supply which may be neutral and free from ability to act on lead, although certain of its contributory waters are possessed of acidity and plumbo-solvency in conspicuous degree. Here, as in the case of Bright Syke Stream, there can be little doubt of the reason.

The result is to be traced to the presence in sufficient amount of other contributory waters of different sort, namely, neutral spring waters, and waters, moreover, possessed of an appreciable degree of acid neutralising ability. Obviously conditions might at times arise which disturb the balance, and if as a fact Bentham Reservoir at other times has been acid and possessed of ability to dissolve lead, the circumstance is not necessarily inconsistent with the facts observed in 1893.

Further, the following waters were subjected to frequent bacterial testing, namely:—

	Average Number of Microbes per c.c.
Inflow water to Bentham Reservoir (18 samples)	2,140
Surface water of Bentham Reservoir (17 samples)	1,862
Water taken near the foot of Bentham Reservoir (16 samples)	2,446
Peat Pool water (8 samples)	190

Lastly, bacteriological examinations were made of numerous samples of Burnmoor peat soil with result as follows :—

Bentham peat soil (surface layers):—30 samples yielded an average of 191,153 *aerobic* microbes per gramme.

Bentham peat soil (samples taken from a little below the surface) :—8 samples yielded an average of 39,063 *aerobic* microbes per gramme.

Bentham peat soil (surface layers) :—13 samples yielded an average of 7,985 *anaerobic* microbes per gramme.

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## Part II.—Results of Surveys of Moorland Gathering Grounds in Lancashire and Yorkshire.

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Prior to the actual commencement of work at Burnmoor, a scheme had been formulated which took note of the necessity of supplementing and extending the information, which it was anticipated would be obtained “locally” at Burnmoor, by careful inspection of the physical characters of other gathering grounds in relation to the quality of water supplied by them, and of comparing the results obtained on one area with those of other and quite separate areas.

The following is a list, alphabetically arranged, of the waterworks of which surveys were made :—

1. Ashton-under-Lyne, Stalybridge, and Dukinfield (District) Waterworks Joint Committee; Lancashire.
2. Bacup Corporation Waterworks; Lancashire.
3. Barnsley Corporation Waterworks; Yorkshire.
4. Barrow-in-Furness Corporation Waterworks; Lancashire.
5. Batley Corporation Waterworks; Yorkshire.
6. Blackburn Corporation Waterworks; Lancashire.
7. Bolton Corporation Waterworks; Lancashire.
8. Bradford Corporation Waterworks; Yorkshire.
9. Burnley Corporation Waterworks; Lancashire.
10. Colne Waterworks; Lancashire.
11. Dewsbury and Heckmondwike Water Board; Yorkshire.
12. Halifax Corporation Waterworks; Yorkshire.
13. Huddersfield Corporation Waterworks; Yorkshire.
14. Keighley Corporation Waterworks; Yorkshire.
15. Leeds Corporation Waterworks; Yorkshire.
16. Morley Corporation Waterworks; Yorkshire.
17. Nelson Corporation Waterworks; Lancashire.
18. Oldham Corporation Waterworks; Lancashire.
19. Preston Corporation Waterworks; Lancashire.
20. Rochdale Corporation Waterworks; Lancashire.
21. Sheffield Corporation Waterworks; Yorkshire.
22. Shipley (Eldwick) Waterworks; Yorkshire.
23. Wakefield Corporation Waterworks; Yorkshire.

Of these 23 waterworks, 11 are situated in Lancashire and 12 in Yorkshire.

Generally speaking, in each survey, general information is given under the heading :—

“Source of the water supply and general description of the water-works,” followed by special notes :—

- (a.) On the characters of the gathering ground.
- (b.) On conditions found to exist on the gathering ground on the date (or dates) of inspection.
- (c.) On the results yielded by the chemical examination of the waters in reference to the observed characters of the gathering ground.

Following on the full particulars respecting each of the gathering grounds surveyed came a careful consideration of the results obtained from the several surveys. The following notes summarise some of the points considered :—

*Particular Natural Conditions of Gathering Grounds in relation to the presence of Peat and to the Plumbo-solvent Ability of Water derived from them.*

Under this heading the following conditions and factors were considered :—

The difference (one of degree rather than of kind) between upland and moorland gathering grounds, with examples of gathering grounds essentially moorland in character, typical moorland gathering grounds, and gathering ground not pre-eminently moorland in character.

Notes on the acidity of moist peat soil on the different gathering grounds.

The distribution of peat, with examples of gathering grounds specially peaty and others less rich in peat.

Consideration of the qualities of peaty water and spring water, and their influence on the questions of acidity and plumbo-solvency.

Possible factors of acidity other than peat, e.g., iron pyrites, acid ruin water, ochre springs, deposits of iron in peat and marl, ferruginous shale and sandstone, &c.

Geological and physical considerations bearing on the general question, for example, the geological formation, denudation of hill slopes, distribution of peat on steep hill slopes, “cropping” out of spring water, surface vegetation, drainage from the soil, &c.

*Certain differential Conditions of the several Waterworks and Gathering Areas surveyed in their relation to Plumbo-solvency.*

Under this heading came notes as to the situation of gathering grounds in relation to the area supplied with water.

Capacity, height (above sea-level), depth, area, &c. of reservoirs.

Different modes of collecting, storing and distributing the water.

The effect of mixing waters of different qualities as regards lead.

Size of drainage areas.

The importance of taking into account the rainfall.

Comparison between “dry weather flow” and “storm water.”

Arrangements for excluding “storm water” from the smaller feeding streams.

The relations of spring and surface waters.

Notes showing that the ultimate state of a mixed moorland water depends on the proportion and degree of acid neutralising ability of the spring water, in relation to the quantity and amount of acidity of the surface peaty water.

Notes on the artificial mixture of neutral spring water with acid peaty water.

Examples showing that some waterworks supply different places within their area of supply with water of different quality.

*Summary of Evidence obtained at the actual Dates of Survey as to the Condition in respect of Plumbo-solvent Ability of untreated Water derived from the several Gathering Grounds visited.*

Under this heading came notes dealing with the following points:—

Variation in the quality of moorland water, according to the rainfall.

Reaction of the water in the reservoirs and the amount of the acidity.

Reaction of the streams “feeding” the reservoirs with water and the amount of the acidity.

Examples of waters neutral during dry weather and acid during storms.

*Treatment of Water adopted at certain of the Waterworks surveyed, and its Efficiency in removing from the Water Ability to dissolve Lead.*

Under this heading, the results of the different kinds of “treatment” of acid waters with a view to removing their plumbo-solvent ability adopted by the different waterworks surveyed were carefully considered.

*Diagrams illustrating the Chemical Results obtained from the above Surveys.*

Under this heading diagrams are given showing that neutral waters are free from solvent action on lead, and acid waters are possessed of plumbo-solvent ability to an extent dependent chiefly on the amount of acid. Further, that the neutral waters chiefly correspond to spring waters and the acid waters to peaty waters.

At the end of the volume certain conclusions were set out as follows:—

1. The history of epidemics of lead poisoning due to water supply, at all events in the north of England, clearly shows that the towns which have suffered in the past derived their water supply from moorland sources. In some cases the water was known to be acid, and in others there was every reason to infer that the water was in a similar condition, since the physical circumstances of the gathering ground were the same.

For example, Sheffield has a “high” and a “low” level supply. Lead poisoning occurred chiefly if not entirely amongst the consumers of the “high-level” supply. This water was proved to be acid, whereas the “low-level” supply was found to be neutral. The “high-level” water was treated with lime which neutralised the acidity, and lead poisoning was no longer observed. Both supplies were derived from upland gathering grounds, but the “high-level” supply was rich in acid peaty water, and contained very little spring water, whereas the “low-level” supply contained a much larger proportion of neutral spring water and very little peaty water.

Similarly Mossley suffered from lead poisoning in 1898. Dr. Copeman in his report to the Board showed conclusively that

lead poisoning was prevalent only in those districts supplied with acid water from Lower Swineshaw reservoir, and that when the neutral water from Brushes reservoir and from the Greenfield Valley (springs) was supplied to the inhabitants there was no lead poisoning. Mossley was kept under observation for a considerable period. Not only was the water in Lower Swineshaw reservoir found to be acid, but the water as delivered to Mossley was also found to be habitually acid and possessed of plumbo-solvent ability. In December 1894, "treatment" of the water was commenced, lime being added to the water in Lower Swineshaw reservoir. Gradually the effect of the "treatment" showed itself in Mossley, and eventually the water became practically neutral and free from plumbo-solvency. Coincident with this change in the quality of the water lead poisoning was no longer complained of. On September 25th, 1895, a visit was paid to Mossley, and the water in Lower Swineshaw reservoir tested. It was found to be practically neutral and free from plumbo-solvent ability.

2. Moorland gathering grounds are usually rich in peat. The amount of peat varies greatly on different gathering grounds, both superficially and in depth.
3. Moist peat has been found to be invariably acid in reaction.
4. The water draining from peat is always acid. The amount of acidity depends chiefly on the amount of peat and the length of time the water has been in contact with it.
5. Acid peaty water dissolves lead.
6. The degree of plumbo-solvency of a water is chiefly governed by the amount of its acidity.
7. Moorland spring water is neutral and often possessed of slight acid-neutralising ability. In virtue of this property spring water is commonly capable of neutralising a certain proportion of acid peaty water.
8. Neutral water does not dissolve lead to any appreciable extent.
9. Moorland waters, as received into storage or service reservoirs, usually contain a mixture in variable amount of acid peaty water and neutral spring water. The reaction of the "mixed" water at any given time is determined by the relative amount of peaty water, and the degree of its acidity, on the one hand, and by the relative amount of spring water, and the degree of its acid neutralising ability on the other.
10. Rain-water is usually neutral, but on some gathering grounds it is slightly acid. Such acidity, however, is quite insufficient to account for the acidity of moorland waters.
11. Water draining from rock rich in iron pyrites may be acid and act on lead. This, however, is not seemingly a common cause of acidity of moorland waters.
12. During dry weather, and especially at the end of a period of dry weather, the water in moorland streams is almost invariably neutral and free from plumbo-solvent ability.
13. During dry weather the water in moorland streams is chiefly composed of spring water: during wet weather the water consists chiefly of surface water draining from peaty soil.
14. During storms the water in moorland streams is usually very acid and acts strongly on lead. Especially is this the case when the wet weather succeeds a period of drought, as then the streams contain the "first washings" of the peat.

15. On most moorland gathering grounds there are areas (particularly on the higher and flatter portions of the gathering grounds) where the rain stagnates in peaty, boggy, and marshy places. Such water has always been found to be acid in reaction.
16. On many gathering grounds a layer of impervious marl underlies the beds of peat. This prevents the escape of the rain in a downward direction, and so the water is "held" in the peat, or escapes only by slow lateral percolation. Thus the peat is always moist, and each successive rainfall washes out of the peat substances formed during the more or less prolonged contact of the water with the peat, rendering the water considerably acid.
17. The "dry weather flow" on most moorland gathering grounds is very small, and is usually quite inadequate to meet the requirements of the town or towns supplied with water.
18. In such cases, during a period of drought, the water in the impounding reservoirs sinks rapidly to a very low level.
19. When heavy rain comes after drought, millions of gallons of acid peaty water are frequently allowed to enter the waterworks. Indeed the storage reservoirs are constructed for this very purpose, namely, to store for future consumption a vast bulk of "storm" water, the ordinary flow of the streams being far too small to keep the reservoirs at their proper level.
20. Thus it not unfrequently happens that, during dry weather, a reservoir water is strongly acid, while all or nearly all the "inlet" streams contain neutral water. In storm time, however, these streams contain not only acid water, but the water in them is usually more acid than the reservoir water itself.
21. Although large quantities of peat are frequently washed into reservoirs, and although the bed of some reservoirs is largely composed of peat, the acidity of the water in moorland reservoirs is not to be traced, or only in small measure, to this circumstance, but to the ingress of large quantities of acid water during storms. No doubt, however, the peat washed into the reservoirs and the peat in the bed of the reservoirs assists in "keeping" the water acid. Laboratory experiments seem to prove that an acid peaty water stored out of contact with peat does not increase in acidity, but tends to lose some of its original acidity.
22. While the cause of plumbo-solvency is to be traced to the presence of acid in the water, and the source of the acid to contact with peat, the antecedent cause of the acidity of moorland waters seems to be associated, at all events in part, with the presence of acid-producing bacteria in the peat itself.
23. Certain microbes isolated from peat possess the power of rendering by their growth a sterile neutral decoction *made solely from peat* both acid and possessed of plumbo solvency.
24. Acid peaty waters have the power of dissolving not only *bright* lead, but old coated lead, and the action is a very rapid one.
25. Neutral waters do not dissolve lead to any appreciable extent, but they sometimes act on *bright* lead by eating away the surface of the metal in the presence of dissolved oxygen ("erosion").
26. The power of "eroding" lead is an inherent property of water containing dissolved oxygen. All waters do not "erode" lead because most of them contain substances which coat the bright surface of the metal and so prevent any further action taking place.

of lead). This compound as it is formed tends to fall away from the surface of the metal, thus leaving a fresh exposed surface ready for further action; and hence it follows that erosion is apt to be progressive in character and correspondingly dangerous. As a matter of fact there are two circumstances which in practice tend to retard or prevent waters from exercising this seemingly inherent property of erosion of lead. One of these is the fact that the metal, by exposure to the air and contact with various substances, acquires in a natural manner a protective coating; and the other is that most waters dissolve in their passage through or over the soil a certain proportion of various salts which tend to inhibit, or altogether to prevent, erosion, and this in an indirect manner, namely, by acting on the bright surface of the metal so as to form an adherent outside layer of a relatively insoluble kind. It thus happens in practice that lead is apt before it is brought into contact with water to have acquired a natural coating. Most waters contain substances which do not really destroy erosive ability, but shield the surface of the metal, and thus restrain or prevent entirely the exercise of this dangerous property. It is important, in considering this question of erosion, to bear in mind the tentative conception of all waters being possessed intrinsically of erosive ability, and that the fact that most waters do not display this attribute is to be ascribed to the presence in them of substances indirectly antagonistic to the exercise of the property of erosion in that they shield the surface of the metal with a protective coating. In this view of the case, all waters are potentially erosive waters: some waters are so in reality, whilst the majority are prevented from displaying erosive ability by the presence in them, in greater or less amount, of "plumbo-protective" substances. This leads to the consideration of substances of which the presence, in greater or less amount, determines whether a water is "remote from" or "near to" the possession of erosive ability. Moorland waters are apt to erode lead, or to be near the possession of erosive ability, because they represent surface water, which is chiefly derived from the peat without coming into prolonged contact with soil, and thereby with the "plumbo-protective" substances to which allusion has just been made. Erosion to any marked extent can seemingly only take place when the lead is *bright*. But it is easy to conceive that the presence of an imperfect coating or some superadded condition, possibly of a temporary character, which tends to remove or dissolve away a pre-existing coating; or some factor which continuously operates against the beneficial influence of the plumbo-protective substances; or the existence of an abnormal length of lead service pipe may, separately or conjointly, tend to render an apparently negligible element of danger real and tangible. It must always be remembered that lead is an insidious and cumulative poison, which may be operative in connexion with water supply only by reason of the minuteness of the poisonous dose or the idiosyncrasy perchance of the individual, or the length of time of its ingestion. All these are points which must needs be borne in mind, lest the broad generalisations which have been or will be made should not be interpreted in a judicious manner, but be narrowed down as applicable to each and every case of water service. Thus waters in general erode lead only when the surface of the metal is *bright*; *neutral* moorland waters are naturally non-erosive in character, although they may tend to be near the possession of this ability; *acid* moorland water may or may not possess erosive ability associated with plumbo-solvency; pure rain-water, snow-water, and neutral distilled water commonly erode lead in vigorous fashion; and natural waters, other than rain or moorland water, do not usually possess ability to erode lead. These statements, therefore, must not be interpreted in too literal a sense, but taken as of

relative value only, and as founded on experiments conducted under laboratory conditions.

As exemplifying some of the points about to be dealt with in detail, as well as those that have just been considered, it will not be out of place to quote from Mr. Power's report as follows:—

*"Pure Rain-water and pure Snow-water.*—These were always found neutral in reaction, and none of the samples examined dissolved lead. All of them, however, eroded lead very vigorously under laboratory conditions.

*"Distilled Water.*—A large number of observations showed that samples of 'acid' freshly-distilled water possessed great lead-dissolving power, but no power at all of eroding this metal. On the other hand, distilled water that was 'neutral' in reaction had practically no ability to dissolve lead, though it eroded the metal vigorously, and in sustained fashion.

*"Moorland Waters.*—Moorland waters that are *acid* invariably possess ability to dissolve lead. At the same time they may, or they may not, erode this metal. Many moorland waters which dissolve lead to a considerable extent possess, in regard of this metal, no conspicuous erosive power. Other moorland waters both dissolve and erode lead in very decided fashion. Moorland *peat* waters are all, it would seem, not far removed from possession of the one or the other property, or of both properties.

"On the other hand moorland *spring* waters are usually free from ability to dissolve or to erode lead. Such waters, indeed, when in admixture with peat water, are capable of lessening or of inhibiting action of the latter on lead.

*"Natural Waters other than Rain or Moorland Waters.*—Such waters (particularly those that have much temporary hardness) do not, as a rule, possess ability to dissolve or to erode lead. Many can, indeed, be experimentally shown to be remote from possession of either property; moreover, addition, even in small amount, of a 'hard' water to distilled water, or to acid moorland waters may, and usually does, remove from them ability to dissolve or to erode lead."

Before dealing with the results of the experiments on erosion, it is necessary to describe in some detail the method adopted.

#### METHOD OF TESTING WATERS AS REGARDS EROSION OF LEAD.

After a variety of methods had been tried, and found open to objection, the following new plan was adopted. Sheet lead was cut into strips, usually about 1 foot long and always  $\frac{1}{4}$  inch wide. One of these strips was laid on a flat piece of hard wood having an even surface. A tool (see Fig. 1, Plate I.), which is employed by plumbers in connection with their work, was used to obtain a clean-cut surface. The cutting edge of the tool was pressed on the lead some few inches from the end of the strip, and then drawn firmly towards the operator along the surface of the metal. This operation repeated several times left a beautifully *clean-cut* surface, the coated lead being as it were shaved off. The strip was then turned over, and the side which had previously rested on the wood treated in exactly the same manner. The clean portion of the strip was then cut transversely, at intervals of 1 inch, thus yielding pieces of *bright* lead (1 inch by  $\frac{1}{4}$  inch) free from adhering particles. A piece of this bright sheet lead was next dropped carefully into a test tube (6 inches by  $\frac{3}{4}$  inch) and 10 c.c. of the



water to be tested added; this amount was more than sufficient to cover the metal. The experiment was then watched at intervals. In the case of most neutral distilled waters an almost immediate effect was usually noted, namely, a milkiness, which (milky looking compound), although formed in the immediate vicinity of the metallic surface, soon became diffused throughout the liquid and later accumulated as a snow-white layer at the foot of the tube. The action was always more or less progressive in character, and the lead either remained bright throughout the progress of the experiment or was partially coated over with a loosely adherent crystalline layer, which continued to fall away in flake-like manner. Taking the opposite extreme, namely, a "hard" natural water, the result was very different, since the bright surface of the metal was observed to become rapidly coated over with a protective bluish-white, dull-looking film, and the water remained quite transparent, there being no trace of milkiness. In such a case it was found that the newly-coated lead could be removed and fresh, bright lead introduced, and that the fresh lead added became coated in the same way, and that this renewal of the lead could be effected time after time for a prolonged period without exhausting the "plumbo-protective" abilities of the water. This gave rise to the plan of renewing the lead from time to time to measure, in the case of a non-erosive water, how near such a water was to the possession of this property of erosion. And as a result it was found that, although many moorland waters just failed to erode lead, the degree of their plumbo-protective ability was of the feeblest kind, since one or two renewals of the lead sufficed to exhaust the protecting substances, and to allow the water to exert its inherent property of erosion in vigorous fashion. Such waters have been classed as "near the possession of erosive ability." Another method of observing experimentally the same phenomenon was employed as an alternative. Here the moorland water was mixed with a certain proportion (usually an equal part) of a distilled water known to be possessed of erosive ability, and the effect watched. Usually, in such cases, the plumbo-protective substances in the moorland water were so diluted that they were unable to restrain erosion from taking place. Several experiments carried out with "hard" waters showed that much greater dilutions with distilled water had no power to prevent the plumbo-protective substance from still coating the lead with a firmly adherent film, which prevented altogether erosion from taking place. So far distilled water has been taken as the type of an erosive water; but of course many moorland waters possess this property also in marked degree, without any preliminary renewal of the lead being required. But usually the action with moorland waters is more slowly developed and there is commonly produced first a sort of imperfect coat on the lead which tends to fall away in places, thus leaving patches open to the erosive action of the water. Erosion, when present, is usually so pronounced as to be clearly and unmistakably visible to the eye. In testing the amount of lead compound thus formed the following plan was adopted. A bent platinum needle was used to draw out the piece of lead, then acid was added to the contents of the tube; after shaking for some time, a quantity of the liquid was withdrawn by means of a pipette, and, after dilution with distilled water to a convenient volume, titrated with a standard solution of lead acetate, ammonium sulphide solution being used as an indicator. The total lead salt produced was determined, and so the lead in solution is included in all the figures given in the tables dealing with erosion. But when erosion takes place the action is commonly so vigorous, and the amount of insoluble lead compound formed so great, that the small amount of lead held in solution by a naturally acid water may reasonably be ignored.

# Plate I

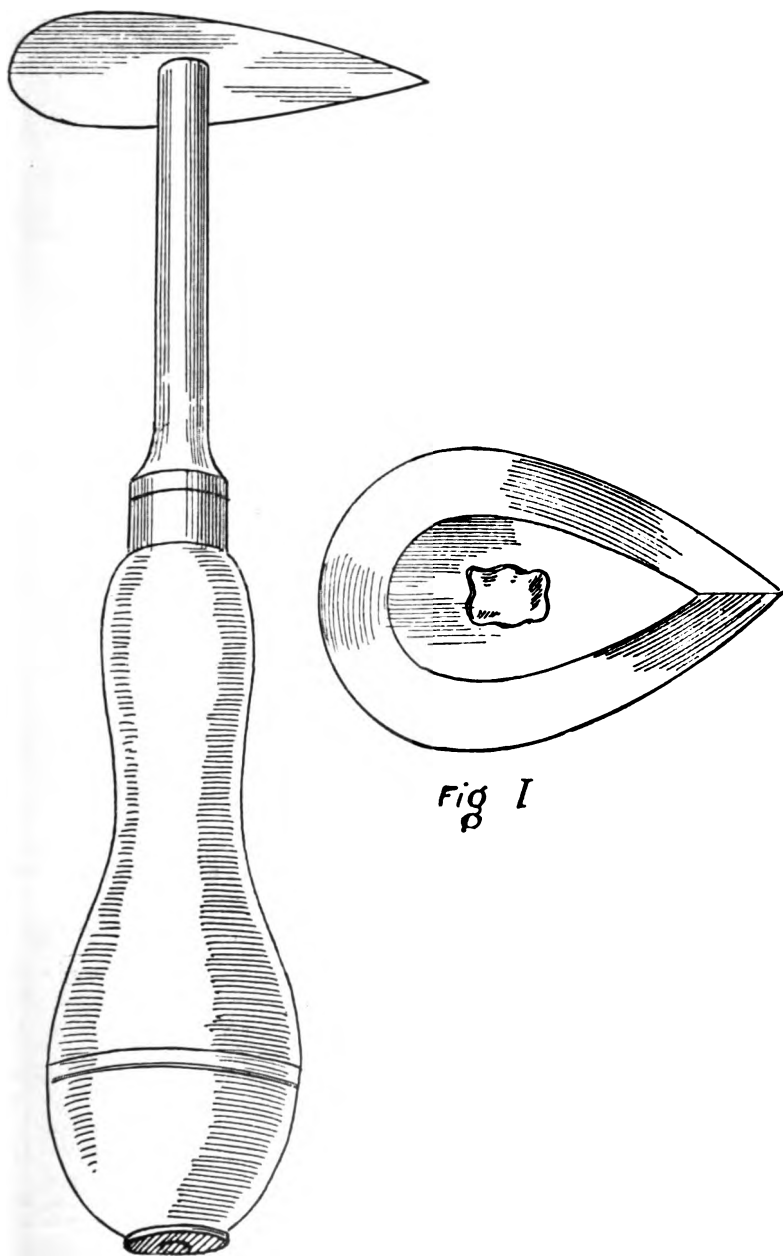


Fig 1

To face page 16.]

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# DIFFERENT WATERS CONSIDERED IN REGARD OF THEIR EROSIVE ABILITY.

## (a).—Pure Rain-water and pure Snow-water.

The dangerous qualities of rain-water, as regards action on lead, have for long been recognised; but their manner of action in every case has not always been so well understood. Rain-water under ordinary conditions is neutral, and therefore cannot dissolve lead to any marked extent; but being free, or relatively so, from "plumbo-protective" substances, its erosive action is usually extremely well marked. Some samples of rain-water, however, collected on high moorlands in the neighbourhood of manufacturing districts, may show, on testing, traces of acid, and such waters undoubtedly are possessed of slight plumbo-solvent ability. They may, and indeed commonly do, erode lead as well; although sometimes the presence of the acid seems to offer at the commencement to the lead a measure of protection and to inhibit erosion from taking place as quickly as it otherwise would do. In the following table (Table I.) the action of pure rain-water and pure snow-water on lead is shown.\*

TABLE I.

Showing the ACTION, as regards EROSION OF LEAD, of RAIN and SNOW WATER.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ " ) completely submerged.]

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Selt (parts per 100,000).
1	August 2nd, 1894. 10 c.c. rain water, (a) collected from roof and (b) directly collected, in test tubes with lead $1 \times \frac{1}{2}$ ". (Plate VIII.)	Neutral	Action commenced at once, and was progressive in character, but more decided in (b) than (a).	No record.
2	August 3rd, 1894. 10 c.c. rain water collected from roof, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral	Action commenced at once, and was progressive in character, but not so decided as in (b). Experiment I.	
3	August 6th, 1894. 10 c.c. rain water, (a) collected from roof and (b) directly collected, in test tube with lead $1 \times \frac{1}{2}$ ". (Plate VIII.)	Neutral	Action commenced at once, and was progressive in character, but more decided in (b) than (a). In (a) lead was partially coated.	
4	August 15th, 1894. 10 c.c. rain water, collected from roof, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral	Action commenced at once, and was progressive in character.	
5	August 17th, 1894. 10 c.c. rain water, collected from roof, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral	Action commenced at once, and was progressive in character.	
6	August 18th, 1894. 10 c.c. rain water, collected from roof, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral	Action commenced at once, and was progressive in character; not so pronounced as in Experiments 4 and 5.	
7	January 14th, 1895. 10 c.c. melted snow, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral	Action commenced almost immediately, and was progressive in character. January 15th, 1895. Lead removed, and acid added.	17.0
8	January 28th, 1895. (a) 10 c.c. melted snow, in test tube with lead $1 \times \frac{1}{2}$ ". (Plate VII.) (b) Ditto.	Neutral	Action commenced at once, and was progressive in character. February 1st, 1895. Lead removed, and acid added.	(a) 30.0 (b) 30.0

\* Plate VII., Fig. 10, and Plate VIII., Fig. 11 (a) and (b).

It will be seen that all the waters experimented with were neutral in reaction and possessed of conspicuous erosive power. The table does not show that the waters were free from plumbo-solvent ability, but taking a line through the distilled water experiments, when a neutral condition was practically always associated with marked erosion and little or no plumbo-solvency, and an acid condition with plumbo-solvency with or without accompanying erosion, the absence of plumbo-solvent ability may almost be inferred with safety. Although the attribute of erosion is being here considered, it is convenient at this stage to include Table II.

TABLE II.

Showing the RESULT, as regards ACIDITY and ACTION on LEAD, of certain EXPERIMENTS with RAIN-WATER collected from MOORLAND GATHERING GROUNDS.

Experiment.	Description of the sample of Rain-water. (All the samples were collected by means of a glass funnel and glass bottle placed in such a position as to avoid splashing from the peak.)	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Plumbo-solvent ability (Results stated as parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						"Erosion" Experiments. 10 c.c. of the rain-water were placed in a test tube with bright sheet lead $1 \times \frac{1}{2}$ . After some time the piece of lead was removed, acid added to the contents of the tube, and the amount of lead estimated. Results stated as parts per 100,000.
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	May 4th, 1896. Rain-water collected on Blackmoorfoot gathering ground. Huddersfield Corporation Water-works.	Acid	0.30	0.1	0.2	0.3	0.3	0.4	0.26	May 4th, two parallel experiments, $\alpha$ and $\beta$ . Tested May 19th, 1896. $\alpha = 80.0$ } "Erosion" $\beta = 80.0$ } very marked.
2	June 28th, 1896. Rain-water collected from the moorland gathering grounds of Oldham Corporation Water-works.	Acid	0.30	0.1	0.1	2	0.2	0.2	0.16	June 28th, two parallel experiments, $\alpha$ and $\beta$ . Tested July 30th, 1896. $\alpha = 90.0$ } "Erosion" $\beta = 90.0$ } very great.
3	June 4th, 1896. Rain-water collected on Blackmoorfoot gathering ground. Huddersfield Corporation Water-works.	Neutral or ? faint trace acid.	Traces				Traces.			
4	June 17th, 1896. Same as in Experiment 3.	Neutral or ? faint trace acid.	Traces				? Traces			June 17th, two parallel experiments, $\alpha$ and $\beta$ . Tested June 27th, 1896. $\alpha = 80.0$ } "Erosion" $\beta = 80.0$ } very marked.
5	July 30th, 1896. Same as in Experiment 3.	Traces acid.	Traces				? Traces			July 30th, two experiments, $\alpha$ and $\beta$ . Tested August 3rd, 1896. $\alpha = 12.5$ } "Erosion" $\beta = 12.5$ } distinct.
6	August 3rd, 1896. Same as in Experiment 2.	Acid	0.24	0.1	0.4	0.4	0.4	0.4	0.34	

Experiment.	Description of the sample of Rain-water. (All the samples were collected by means of a glass funnel and glass bottle placed in such a position as to avoid splashings from the peat.)	Reaction with Lacomoid.	Acidity in Terms of c.c. of $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Plumbo solvent ability (Results stated as parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Average.	"Erosion" Experiments. 10 c.c. of the rain-water were placed in test tube with bright sheet lead $1 \times \frac{1}{8}$ ". After some time the piece of lead was removed, acid added to the contents of the tube, and the amount of lead estimated. Results stated as parts per 100,000.
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.			
7	August 11th, 1896. Same as in Experiment 3.	? Trace acid.	? Trace acid.	? Traces.							
8	October 9th, 1896. Same as in Experiment 3.	Trace acid.	0.18	0.1	0.2	0.2	0.2	0.3	0.20		October 9th, two parallel experiments, <i>a</i> and <i>b</i> . Tested November 6th, 1896. $a=70.0$ } Marked $b=70.0$ } "erosion."
9	November 3rd, 1896. Same as in Experiment 3.	Trace acid.	0.18	0.2	0.2	0.2	0.2	0.2	0.20		November 3rd, two experiments, <i>a</i> and <i>b</i> . Tested November 13th, 1896. $a=12.5$ } "Erosion" $b=12.5$ } distinct.
10	November 13th, 1896. Same as in Experiment 2.	Acid	0.36	0.4	0.4	0.4	0.4	0.4	0.40		November 13th, two parallel experiments, <i>a</i> and <i>b</i> . Tested December 10th, 1896. $a=90.0$ } "Erosion" $b=90.0$ } very great.
11	December 10th, 1896. Same as in Experiment 2.	Slightly acid.	0.30	0.1	0.1	0.1	0.1	0.1	0.10		December 10th, two parallel experiments, <i>a</i> and <i>b</i> . Tested December 28th, 1896. $a=30.0$ } "Erosion" $b=30.0$ } distinct.
12	December 28th, 1896. Same as in Experiment 2.	Acid	0.24	0.2	0.2	0.2	0.2	0.2	0.20		December 28th, two parallel experiments, <i>a</i> and <i>b</i> . Tested January 15th, 1897. $a=30.0$ } "Erosion" $b=30.0$ } distinct.
13	January 15th, 1897. Same as in Experiment 3.	Acid	0.24	0.2	0.2	0.2	0.2	0.2	0.20		January 15th, two parallel experiments, <i>a</i> and <i>b</i> . Tested February 14th, 1897. $a=60.0$ } "Erosion" $b=50.0$ } very great.
14	February 13th, 1897. Same as in Experiment 2.	Very acid.	0.36	0.6	0.6	0.6	0.6	0.6	0.60		February 13th, two parallel experiments, <i>a</i> and <i>b</i> . Tested March 2nd, 1897. $a=50.0$ } "Erosion" $b=60.0$ } very great.
15	March 2nd, 1897. Same as in Experiment 3.	Acid	0.24	0.2	0.3	0.4	0.4	0.4	0.34		March 2nd, 1897, two parallel experiments, <i>a</i> and <i>b</i> . Tested March 24th, 1897. $a=40.0$ } "Erosion" $b=40.0$ } very great.

In all the samples the water was more or less turbid, there being a considerable deposit, and the testing for acidity and plumbo-solvent ability was often very difficult.  
The samples were said to be collected in such a way as seemingly to prevent the possibility of splashings from the peat.

It will be noted that the rain-water was collected in glass funnels and glass bottles placed in such a position as to avoid splashing\* from the peat and on high moorland gathering grounds in the neighbourhood of manufacturing cities. Here the rain-water was usually found to be faintly acid and to dissolve lead to a slight but appreciable extent. It must be understood, however, that the acidity and plumbo-solvent ability of the water were never so marked as to offer any adequate explanation of the acidity and plumbo-solvent ability observed in the case of most moorland peaty waters. The same samples of rain-water also eroded lead in vigorous fashion, although it was not uncommonly noticed that the presence of the acid seemed at first to inhibit this property.

(b.)—*Distilled Water with and without addition of various Chemical Substances.*

The records under this heading are very numerous, and although it is proposed to let the various tables tell as far as possible their own tale, some explanatory statement must first be made. So varied and contradictory were the opinions expressed on the subject of the action of distilled water on lead that it was deemed desirable at the start of the investigation to begin, as it were, at the very beginning, and study the subject unhampered by attention to any preconceived theories. Accordingly a water was chosen (Settle water, a hard limestone water) and this was distilled (in bulk equal to four Winchester quarts three parts full), always in the same manner and in such a way as to yield three successive lots called X, XX, and XXX, in bulk in each case corresponding to a Winchester quart bottle three-quarters full. In the table on the opposite page (Table III.) the characteristics of these separate lots (X, XX, XXX) of distilled water are described.

It will be seen that X water was distinctly acid, contained free ammonia, had practically no erosive power, but dissolved lead to a marked extent. In strong contrast to this, XXX water was neutral, contained only traces of ammonia, eroded lead in vigorous fashion, but was possessed of little or no plumbo-solvent ability. XX water occupied on the whole an intermediate position. All three waters contained about the same amount of dissolved oxygen. As regards the plumbo-solvent ability of these waters, a passing reference may be made to Table III. This table will be considered later in connection with the general question of the plumbo-solvent ability of various waters. Here it is only necessary to remark that X water was always distinctly acid and dissolved lead to a considerable extent; that XXX was either neutral or contained only traces of acid, and had on lead either no, or only a trivial action, in respect of plumbo-solvency. XX water occupied an intermediate position, but usually bore a greater resemblance to X water than XXX water. Other tables relating to the plumbo-solvent abilities of distilled water will be considered in a separate section of the report. Reverting once more to the question of erosion, certain tables may here be given, which chiefly afford evidence that the non-erosive character of X distilled water was a temporary condition associated with the presence of a volatile acid.†

\* It was impossible, of course, to make absolutely certain that no "splashing" from the peat ever reached the bottles. During heavy storms of wind and rain spray from the ground may be carried a considerable distance.

† Plate IX., Fig. 12 (a). Plate X., Fig. 13 A. B. C. Plate XIII., Fig. 16 (a), (b), (c). Plate XIV., Fig. 17 (a), (d), (e).

TABLE III.  
Showing the CHARACTERISTICS of the DISTILLED WATERS described in the text as—  
X, XX, and XXX Distilled Water.

Description of the Distillation Process.	Reaction with Læmroid.			Ammonia.		Dissolved Oxygen.	Action on Lead.						
	X.	XX.	XXX.	X.	XX.		"Erosion" of Lead.		Plumbo-solvent ability.				
							X.	XX.		XXX.			
4 Winchester quartz (½ full) distilled in copper distillation apparatus: the first Winchester quart (½ full) labelled X, the second XX, and the third XXX.	Distinctly acid.	Slightly acid.	Neutral or traces of acidity.	Present	Present	Trace	No distinct difference in the amount of dissolved oxygen could be detected between X, XX, and XXX.	Practically none.	Sometimes action and sometimes not.	Very marked.	Very great.	Distinct	Little or none.



Table IV. shows the effect, as regards erosion of lead, of keeping X distilled water in bottles (a) partially filled and unstoppered, and (b) completely filled and stoppered.

TABLE IV.

Showing the EFFECT, as regards EROSION of LEAD, of keeping X DISTILLED WATER in BOTTLES, (a) Partially Filled and Unstoppered, and (b) Completely Filled and Stoppered.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ) completely submerged.]

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Salt (parts per 100,000).
1	(a.) 10 c.c. distilled water X in test tube with lead $1 \times \frac{1}{4}$ ".	(a.) Acid -	(a) No action noticeable even after several days, but lead coated with bluish-white film.	No record.
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 13 days.	(b.) Neutral	(b.) Action commenced at once, and was progressive in character.	
2	(a.) 10 c.c. distilled water X in test tube with lead $1 \times \frac{1}{4}$ ".	(a.) Acid -	(a.) No action noticeable, even after several days, but lead was coated with bluish-white film.	No record.
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 12 days.	(b.) Neutral	(b.) Action began at once and was progressive in character.	
3	(a.) 10 c.c. distilled water X in test tube with lead $1 \times \frac{1}{4}$ ".	(a.) Acid -	(a.) No action noticeable, even after several days, but lead coated with bluish-white film.	No record.
	(b.) Same as (a) but water kept previously in a bottle only partially filled and unstoppered for 8 days.	(b.) Neutral	(b.) Action began at once, and was progressive in character.	
4	(a.) 10 c.c. distilled water X in test tube with lead $1 \times \frac{1}{4}$ ".	(a.) Acid -	(a.) No action noticeable even after several days, but lead coated with bluish-white film.	No record.
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 14 days.	(b.) Neutral	(b.) Action began at once, and was progressive in character.	
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 14 days.	(c.) Acid -	(c.) Same result as in case of (a).	
5	(a.) 10 c.c. distilled water X in test tube with lead $1 \times \frac{1}{4}$ ".	(a.) Acid -	(a.) No action noticeable, even after several days, but lead coated with bluish-white film.	—
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 7 days.	(b.) Neutral	(b.) Action began at once, and was progressive in character.	
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 7 days.	(c.) Acid -	(c.) Same result as in case of (a.) After one day lead removed and acid added.	

(b.) 35.0

(c.) 0.5

TABLE IV.—*continued.*

No.	Description of Experiment.	Reaction	Remarks.	Total Lead Salt (parts per 100,000).
6	(a.) 10 c.c. distilled water X in test tube with lead $1 \times \frac{1}{4}$ ".	(a.) Acid -	(a.) No action noticeable, even after several days, but lead coated with bluish-white film.	—
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 44 days.	(b.) Neutral	(b.) Action began at once, and was progressive in character.	(b.) 10.0
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 44 days.	(c.) Acid -	(c.) Same result as in case of (a). After one day lead removed and acid added.	(c.) 0.5
7	(a.) 10 c.c. distilled water X in test tube with lead $1 \times \frac{1}{4}$ ".	(a.) Acid -	(a.) No action noticeable even after several days, but lead coated with a bluish white film.	—
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 83 days.	(b.) Neutral	(b.) Action began at once, and was progressive in character.	(b.) 10.0
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 83 days.	(c.) Acid -	(c.) Same result as in case of (a). After two days lead removed and acid added.	(c.) Trace.

It will be seen that X distilled water, in the fresh condition, was acid, and did not erode lead, but coated the bright surface of the metal with a bluish-white adherent film, and this film protected the lead from erosion. Similarly X distilled water, kept for long periods in completely filled and stoppered bottles, behaved as if it were still fresh as regards lack of ability to erode lead and retention of its originally acid quality. But the same water, after being stored in bottles, only partially filled and unstoppered, for some time, became altered to a material extent, and in the direction of simulating a XXX distilled water, in that it gave a neutral reaction and eroded lead in vigorous fashion. (Plate XIII., Fig. 16 (a), (c).)

Parallel experiments were carried out with XXX distilled water, and these are shown in Table V.

TABLE V.

Showing the EFFECT, as regards EROSION of LEAD, of keeping XXX DISTILLED WATER in BOTTLES, (a) Partially Filled and Unstoppered and (b) Completely Filled and Stoppered.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ " ) completely submerged.]

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Salt (parts per 100,000).
1	(a.) 10 c.c. distilled water XXX in test tube with lead $1 \times \frac{1}{2}$ ".	(a.) Neutral	(a.) Action commenced at once, and was progressive in character.	No record.
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 14 days.	(b.) "	(b.) " "	
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 14 days.	(c.) "	(c.) " "	
2	(a.) 10 c.c. distilled water XXX in test tube with lead $1 \times \frac{1}{2}$ ".	(a.) Neutral	(a.) Action commenced at once, and was progressive in character.	—
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 7 days.	(b.) "	(b.) " "	
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 7 days.	(c.) "	(c.) After one " day lead removed and acid added.	
3	(a.) 10 c.c. distilled water, XXX in test tube with lead $1 \times \frac{1}{2}$ ".	(a.) Neutral	(a.) Action commenced at once, and was progressive in character.	—
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 44 days.	(b.) "	(b.) " "	
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 44 days.	(c.) "	(c.) After one " day lead removed and acid added.	
4	(a.) 10 c.c. distilled water XXX in test tube with lead $1 \times \frac{1}{2}$ ".	(a.) Neutral	(a.) Action commenced at once, and was progressive in character.	—
	(b.) Same as (a), but water kept previously in a bottle only partially filled and unstoppered for 83 days.	(b.) "	(b.) " "	
	(c.) Same as (a), but water kept previously in a bottle completely filled and stoppered for 83 days.	(c.) "	(c.) After two " days lead removed and acid added.	

It will be noted XXX distilled water under all three sets of conditions (fresh ; stored in partially filled and unstoppered bottles ; and in completely filled and stoppered bottles) was found to be neutral and possessed of conspicuous erosive power.

The following three tables (VI., VII., and VIII.) deal respectively with the effects of—(1) boiling and then cooling ; (2) exhausting the air and then allowing aeration to take place ; and (3) artificial aeration of distilled waters X, XX, XXX, as regards reaction and erosive ability. (Plate IX., Fig. 12 ; Plate X., Fig. 13 ; Plate XIII., Fig. 16 ; Plate XIV., Fig. 17.)

TABLE VI.

Showing the EFFECT, as regards EROSION of LEAD, of Boiling  
X, XX, and XXX DISTILLED WATER respectively.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	<p>March 28th, 1894.—Samples of X (distinctly acid), XX (slightly acid), and XXX (neutral) distilled water heated to 100° C. for several minutes in platinum dish. The water left to cool and re-absorb oxygen from the air. X, XX, XXX water now neutral:—</p> <p>(a.) 10 c.c. X water in test tube with lead <math>1 \times \frac{1}{2}</math>".</p> <p>(b.) 10 c.c. XX water in test tube with lead <math>1 \times \frac{1}{2}</math>".</p> <p>(c.) 10 c.c. XXX water in test tube with lead <math>1 \times \frac{1}{2}</math>".</p>	Distinct erosion of the lead in the three test tubes (a), (b), (c) occurred.	No records.
2	<p>March 29th, 1894.—Samples of X (distinctly acid), XX (slightly acid), and XXX (neutral) distilled water heated to 100° C. for several minutes in platinum dish. The water rapidly cooled, and introduced into test tubes (a), (b), and (c) with lead <math>1 \times \frac{1}{2}</math>".</p> <p>10 c.c. of X, XX, and XXX water which had not been heated also introduced into test tubes (d), (e), and (f) with lead <math>1 \times \frac{1}{2}</math>".</p>	At first there was no action in (a), (b), (c), but gradually, as oxygen was absorbed, action commenced. In the case of (d), (e), and (f) usual phenomena observed, i.e., no action in X (d), slight action in XX (e), and great action in XXX (f).	
3	<p>May 31st, 1894:—</p> <p>(a.) 10 c.c. X (distinctly acid) distilled water in test tube with lead <math>1 \times \frac{1}{2}</math>".</p> <p>(b.) Same as (a), but water first heated to 100° C. in porcelain dish for several minutes, and then allowed to cool and re-absorb oxygen. This water was now neutral.</p>	No action occurred in (a), but in (b) a very decided action took place.	
4	July 18th, 1894.—Experiment No. 3 (a and b) repeated, but with freshly distilled water.	Same result as in Experiment 3.	
5	<p>July 25th, 1894.—Samples of X (distinctly acid) and XXX (neutral water) distilled water heated to 100° C. for several minutes in platinum dish. The water allowed to cool and re-absorb oxygen. X and XX water now neutral:—</p> <p>(a.) 10 c.c. X with lead <math>1 \times \frac{1}{2}</math>".</p> <p>(b.) 10 c.c. XXX with lead <math>1 \times \frac{1}{2}</math>".</p>	The action on lead was very decided in (a) and (b).	
6	July 26th, 1894. Experiment 5 (a and b) repeated, but with freshly distilled water.	Same result as in Experiment 5, but the action on lead in both cases not quite so great.	
7	<p>August 2nd, 1894:—</p> <p>(a.) 10 c.c. X (distinctly acid) distilled water in test tube with lead <math>1 \times \frac{1}{2}</math>".</p> <p>(b.) Same as (a), but XXX (neutral) water used.</p> <p>(c.) Same as (a), but X water previously heated to 100° C. for several minutes, and then allowed to cool and re-absorb oxygen. Water now neutral.</p> <p>(d.) Same as (c), but XXX water used.</p>	No action on lead in (a), but distinct action in (b), (c), and (d).	
8	August 10th, 1894. Experiment 7 (a, b, c, d) repeated, but with freshly distilled water.	Same result as in Experiment 7.	
9	January 27th, 1895. Experiment 7 repeated, but with freshly distilled water.	January 31st, 1895. No action in (a), but great action (b), (c), (d). Lead removed, acid added, and lead estimated.	(a.) = 0.5 (b.) = 20.0 (c.) = 20.0 (d.) = 25.0
10	<p>February 1st, 1895:—</p> <p>(a.) 10 c.c. XXX (neutral) distilled water in test tube with lead <math>1 \times \frac{1}{2}</math>".</p> <p>(b.) Same as (a), but water previously heated to 100° C. for several minutes in platinum dish, and then allowed to cool and re-absorb oxygen.</p>	Action commenced at once in (a) and (b).	

TABLE VII.

Showing the EFFECT, as regards EROSION of LEAD, of Exhausting the AIR from DISTILLED WATER, and then allowing the WATER to become Aerated again.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ "') completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	May 31st, 1894:— (a.) 10 c.c. X (distinctly acid) distilled water in test tube with lead $1 \times \frac{1}{4}$ ".  (b.) Same as (a), but water previously exhausted of air, and then air allowed to re-enter. The water was now neutral.	Action began at once in b. No action was visible in a.	No records.
2	July 25th, 1894:— (a.) 10 c.c. X (distinctly acid) distilled water in test tube with lead $1 \times \frac{1}{4}$ ".  (b.) 10 c.c. XXX (neutral) distilled water in test tube with lead $1 \times \frac{1}{4}$ ".  (c.) Same as (a), but water previously exhausted of air, and then air allowed to re-enter. The water was now neutral.  (d.) Same as (b), but water previously exhausted of air, and then air allowed to re-enter.	Action began at once in b, c, d.  No action was visible in a.	
3	July 26th, 1894.—Experiment 2 repeated with fresh samples of distilled water.	Same result as in Experiment 2.	
4	August 2nd, 1894.—Experiment 2 repeated with fresh samples of distilled water.	Same result as in Experiment 2.	
5	August 10th, 1894.—Experiment 2 repeated with fresh samples of distilled water.	Same result as in Experiment 2.	
6	January 27th, 1895.—Experiment 2 repeated with fresh samples of distilled water.	Same result as in Experiment 2. January 31st, 1895. Lead removed from tubes, acid added to their contents, and lead estimated.	
			a = 0.5 b = 20.0 c = 25.0 d = 20.0

TABLE VIII.

Showing the EFFECT, as regards EROSION of LEAD, of the AERATION of DISTILLED WATER.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	Atmospheric air aspirated first through wash bottle (containing water), and then through X (distinctly acid), XX (slightly acid) and XXX (neutral) distilled water in flasks for $\frac{1}{2}$ hour. X, XX, and XXX distilled water now neutral. (a.) 10 c.c. X in test tube with lead $1 \times \frac{1}{4}$ ". (b.) " XX " " " (c.) " XXX " " "	Erosion commenced at once in (a), (b), and (c).	Not recorded.
2	July 25th, 1894.—Experiment 1 repeated with freshly distilled samples of X and XXX water. (a.) 10 c.c. X in test tube with lead $1 \times \frac{1}{4}$ ". (b.) " XXX " " "	Erosion commenced at once in (a) and (b).	
3	July 26th, 1894. Experiment 1 repeated with freshly distilled samples of X and XXX water. (a.) 10 c.c. X in test tube with lead $1 \times \frac{1}{4}$ ". (b.) " XXX " " "	Erosion commenced at once in (a) and (b).	
4	August 2nd, 1894. Experiment 1 repeated with freshly distilled samples of X and XXX water. (a.) 10 c.c. X in test tube with lead $1 \times \frac{1}{4}$ ". (b.) " XXX " " "	Erosion commenced at once (a) and (b).	
5	August 10th, 1894. Experiment 1 repeated with freshly distilled samples of X and XXX water. (a.) 10 c.c. X in test tube with lead $1 \times \frac{1}{4}$ ". (b.) " XXX " " "	Erosion commenced at once in (a) and (b).	
6	January 27th, 1895. Experiment 1 repeated with freshly distilled samples of X and XXX water. (a.) 10 c.c. X in test tube with lead $1 \times \frac{1}{4}$ ". (b.) " XXX " " "	Erosion commenced at once in (a) and (b).	
7	February 6th, 1895 :— (a.) 10 c.c. freshly distilled X water in test tube with lead $1 \times \frac{1}{4}$ ". Water acid. (b.) Same as (a.), but air (previously washed by passing through wash bottle containing water) first passed through for $\frac{1}{2}$ hour. X water now neutral. (c.) Same as (b), but dilute solution of KHO in wash bottle. X water now neutral. (d.) Same as (b), but two wash bottles used, the first containing dilute HCl, and the second water. X water now neutral.	Erosion commenced at once in (b), (c), and (d), but there was no action in (a). February 7th, 1895, lead removed from tubes, acid added, and lead estimated.	a. = 1.0 b. = 12.5 c. = 12.5 d. = 12.5

It will be noted that an acid non-erosive X distilled water can be brought into the condition of a neutral erosive water (comparable to XXX) by one of the following methods:—(1) boiling and then cooling, and allowing the water to re-absorb oxygen (Table VI.); or (2) exhaustion of the gases and then allowing natural aeration to take place (Table VII.); or (3) artificial aeration. In all three cases the effect produced on the water, and the ultimate result obtained, as regards action on lead, was the same, namely, removal of the volatile inhibitory "plumbo protective" substance and the introduction of atmospheric oxygen resulting in loss of acidity and gain in ability to erode lead. It will be shown in another section of this report that the change of an acid non-erosive X distilled water into a neutral erosive, and practically XXX distilled water is also associated with a loss of the previously possessed ability to dissolve lead (plumbo-solvent ability).

There remains to be mentioned another method by means of which an acid non-erosive X distilled water can be converted into an erosive water (Table IX.).

TABLE IX.

Showing the ACTION, as regards EROSION of LEAD, of X DISTILLED WATER upon BRIGHT SHEET LEAD—(a) under Ordinary Conditions, (b) upon Renewal of Lead.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
1	May 29th, 1895:— (a.) 10 c.c. X distilled water (acid), in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) May 30th and 31st. June 6th, action in (a), (b), but greater in (b) than (a).	(a.) 15.0 (b.) 25.0
2	June 1st, 1895:— (a.) 10 c.c. X distilled water (acid), in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) June 2nd, 3rd, and 4th. June 7th, no action visible in (a), distinct action in (b).	(a.) 1.0 (b.) 10.0
3	June 12th, 1895:— (a.) 10 c.c. X distilled water (acid), in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) June 13th, 14th, 15th, and 16th. June 18th, no action visible in (a), distinct action in (b).	(a.) 0.5 (b.) 15.0
4	June 14th, 1895:— (a.) 10 c.c. X distilled water (acid), in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) June 15th and 16th. June 18th, no action visible in (a), distinct action in (b).	(a.) 0.5 (b.) 10.0

It will be seen that, by renewing the lead at intervals, the "plumbo-protective" substance originally present in an X distilled water can be exhausted, thus allowing the inherent property of erosion to act in unrestrained fashion (Plate VIII., Fig. 11).

It has been asserted that the kind of action on lead, here termed erosion, is not an inherent property of a *pure* water containing dissolved oxygen, but that it is due to the presence of impurities in the water. With the view of testing this hypothesis, the experiments detailed in Table X. were carried out.

TABLE X.

Showing the EFFECT, as regards EROSION of LEAD, of the  
RE-DISTILLATION of XXX DISTILLED WATER.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ "') completely submerged.]

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Salt (parts per 100,000).
1	November 12th, 1894. 1,000 c.c. XXX distilled, 1st 100 rejected, 700 collected. 700 c.c. distilled, 1st 50 rejected, 450 c.c. collected. 450 c.c. distilled, 1st 50 rejected, 200 collected. 200 c.c. distilled, 1st 50 rejected, 50 collected; 10 c.c. of the last 50 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral	Action began at once, and was progressive in character. November 13th, 1894. Action very distinct; lead removed and acid added.	10·0
2	November 21st, 1894. 1,000 c.c. XXX, with a crystal $\text{KMnO}_4$ , distilled till volume reduced to 250 c.c.; 50 c.c. then collected; 10 c.c. of this 50 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral	Action commenced at once, and was progressive in character. November 22nd, 1894. Lead removed, and acid added.	5·0
3	November 24th, 1894. 2,000 c.c. XXX distilled, 1st 100 c.c. rejected, and 1,700 collected. 1,700 c.c. distilled, 1st 100 rejected, 1,400 collected. 1,400 c.c. distilled, 1st 100 rejected, 1,200 collected. 1,200 c.c. distilled, 1st 200 rejected, next 100 c.c. collected.	-	Action commenced at once, and was progressive in character. November 25th, 1894. Lead removed and acid added.	
	(a.) 10 c.c. of this 100 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral	- - - - -	(a.) 5·0
	(b.) 10 c.c. of this 100 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	"	- - - - -	(b.) 7·0
4	January 31st, 1895. 2,000 c.c. XXX distilled, with 50 c.c. alkaline $\text{KMnO}_4$ ( $\text{KHO}$ 1 in 5, and $\text{KMnO}_4$ 1 in 125), previously boiled free of ammonia; 1,600 c.c. rejected, and 100 c.c. collected, ammonia free.	-	Action commenced at once, and was progressive in character. February 2nd, 1895. Lead removed, and acid added.	
	(a.) 10 c.c. of this 100 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral	- - - - -	(a.) 15·0
	(b.) 10 c.c. of this 100 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	"	- - - - -	(b.) 15·0
5	February 7th, 1895. 1,000 c.c. X distilled with 0·1 per cent. $\text{Na}_2\text{CO}_3$ , 1st 200 c.c. rejected, and 600 c.c. collected. 600 c.c. distilled with 0·1 per cent. $\text{Na}_2\text{CO}_3$ , 1st 100 c.c. rejected, and 500 c.c. collected. 500 c.c. distilled, 1st 50 c.c. rejected, and 150 c.c. collected, ammonia free; 10 c.c. of this 150 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral	Action commenced at once, and was progressive in character.	

The table shows that the repeated distillations of XXX distilled water (so as to obtain samples of distilled water in as pure a condition as possible) in no way affected its power of eroding lead in vigorous fashion.

It is convenient next to pass to a consideration of Table XI., which shows the effect, as regards erosion of lead, of passing hydrogen gas through distilled water.



TABLE XI.

Showing the EFFECT, as regards EROSION of LEAD, of passing  
HYDROGEN GAS through DISTILLED WATER.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	March 26th, 1894. Hydrogen gas passed through X (distinctly acid), XX (slightly acid), and XXX (neutral) distilled water in flasks, for $\frac{1}{2}$ hour. X, XX, XXX water now neutral. (a.) 10 c.c. X in test tube with lead $1 \times \frac{1}{4}$ ". (b.) " XX " " " (c.) " XXX " " "	A slight action on lead was noticeable, in (a), (b), and (c). This result was no doubt to be traced to presence in the water of some oxygen.	No records.
2	April 9th, 1894. 100 c.c. X, XX, and XXX distilled water in flasks. Hydrogen drawn through $\frac{1}{2}$ hour. Pieces of lead ( $1 \times \frac{1}{4}$ " ) introduced and hydrogen again drawn through $\frac{1}{2}$ hour. Flasks stoppered so as to exclude air.	April 9th and 10th. No action visible. Air then drawn through for $\frac{1}{2}$ hour. Erosion slowly commenced in all 3 flasks, and by April 11th the action on the lead was well marked.	
3	April 12th, 1894. Experiment same as No. 2, but fresh samples of distilled water used.	No action visible after $\frac{1}{2}$ hour. Air now passed through water in one of the flasks for $\frac{1}{2}$ hour. Erosion of lead soon occurred, and progressively increased in amount. April 13th. A very slight action noticed in the other two flasks. The stoppers of these two flasks removed with the result that decided erosion of the lead followed.	
4	January 27th, 1895 :— (a.) 10 c.c. X (distinctly acid) distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX (neutral) distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (c.) Same as (a), but hydrogen gas previously passed through X water, and then water allowed to become aerated again. The water was now neutral. (d.) Same as (b), but hydrogen gas previously passed through XXX water, and then water allowed to become aerated again.	No action occurred in (a). Action distinct in (b), (c), (d).	No record.

The table shows that X, XX, and XXX distilled waters, when saturated with hydrogen gas, display practically no erosive power, but that this treatment removes the acidity originally possessed by waters X (in marked degree) and XX (in less degree). Further, that if, either artificially or by natural processes, air be allowed to take the place of the hydrogen, decided erosion ensues. Thus, by passing hydrogen gas through an acid non-erosive X water or a neutral erosive XXX water, the former is rendered neutral but remains non-erosive, whilst the latter loses its original power of eroding lead. In both cases the removal of the hydrogen, by artificial or natural processes of aeration, results in the display of distinct erosive ability.

Table XII. shows that a distilled water, which erodes lead, loses its power of eroding lead when placed under anaerobic conditions.



# Plate II

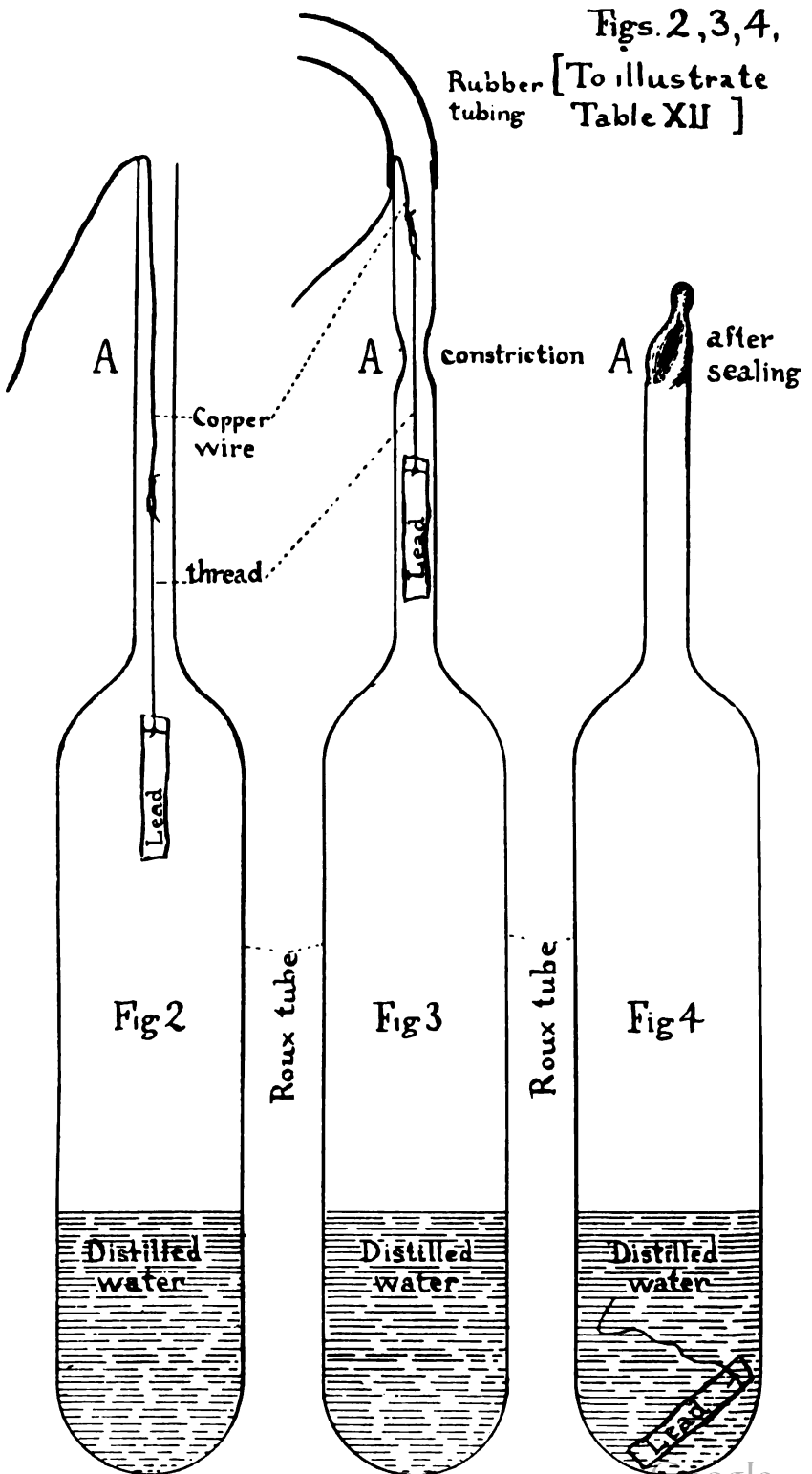


TABLE XII.

Showing that a DISTILLED WATER which "ERODES" LEAD loses its POWER of "ERODING" LEAD under ANAEROBIC CONDITIONS.

Experiment.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	<p>(a.) 10 c.c. XXX distilled water in Roux tube with strip of bright sheet lead. March 29th, 1894.</p> <p>(b.) Same as (a) but the air first exhausted in the following way. A piece of thread was tied to a strip of bright sheet lead, and a length of thin copper wire to the thread—the lead being suspended in a Roux tube in the way shown in Fig. 3, Plate II. A constriction was made at a and when the glass had cooled sufficiently the wire was drawn up until the thread was opposite the constriction.—Fig. 3, Plate II. The tube was connected by a piece of rubber tubing with a Roux's apparatus, and the air exhausted with a water pump and then hydrogen admitted; the alternate exhaustion of the air and admission of hydrogen being continued several times to remove the last traces of oxygen. After the final exhaustion the tube was sealed at the constriction—thus causing the thread to break and the lead to fall into the water.—Fig. 4, Plate II.</p>	<p>March 30th, 1894. Great action in (a), none in (b).</p> <p>April 2nd, 1894. Great action in (a), none in (b).</p> <p>April 3rd, 1894. Great action in (a), none in (b).</p> <p>April 6th, 1894. The neck of (b) tube broken so as to admit the air.</p> <p>April 7th, 1894. Still no action in (b).</p> <p>April 8th, 1894. so a fresh strip of bright lead introduced into (b).</p> <p>April 12th, 1894. No action however took place.</p>	
2	<p>(a.) Same as (b) Experiment 1. April 2nd, 1894.</p> <p>(b.) Same as (b) Experiment 1. April 2nd, 1894.</p>	<p>No action in (a) and (b). April 3rd, 4th, and 5th.</p> <p>April 6th. (a) broken so as to admit air.</p> <p>April 6th. Still no action in (a) or (b), so a fresh strip of lead introduced into (a) tube. Action slowly commenced in (a).</p> <p>April 7th. (b) tube now broken.</p> <p>April 8th, 9th. No action in (b), so fresh lead introduced.</p> <p>April 12th. Now action in both (a) and (b).</p>	Not recorded.
3	<p>(a.) 10 c.c. XXX distilled water in Roux tube with strip of bright sheet lead. April 2nd, 1894</p> <p>(b.) Same as (b) Experiment 1.</p> <p>(c.) " " "</p>	<p>Action began at once in (a), no action in (b), (c). April 6th, still no action in (b), (c); so (b) tube broken.</p> <p>April 7th, still no action in (b), (c), so fresh lead introduced into (b) tube. April 8th, slight action in (b), none in (c), so tube (c) broken.</p> <p>April 9th, 12th, still no action in (c).</p>	
4	<p>(a.) 10 c.c. XXX distilled water in Roux tube with strip of bright sheet lead. April 5th, 1894.</p> <p>(b.) Same as (b) Experiment 1.</p> <p>(c.) " " "</p>	<p>Action began at once in (a), but not in (b), (c). After <math>\frac{1}{2}</math> hour (b) tube broken. April 6th, now action in (b), none in (c), so (c) tube broken. By April 7th, 1894, action in (a), (b), and (c).</p>	
5	<p>(a.) 10 c.c. XXX distilled water in Roux tube. Air first exhausted and then strip of bright sheet lead introduced; a constriction made on neck of tube, and exhaustion again made, and finally sealed at point of constriction April 6th, 1894.</p>	<p>A slight action noticeable, perhaps due to traces of oxygen introduced with piece of lead. After 1½ hours tube broken, and the action then progressively increased.</p>	

TABLE XII.—*continued.*

Experiment.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
6	(a.) 10 c.c. XXX. distilled water in Roux tube with strip of bright sheet lead. April 12th, 1894. (b.) Same as (b), Experiment 1. (c.) " " " (d.) " " "	Action only in (a). After half an hour (b) tube broken. April 13th. (a), (b) distinct action; (c), (d) no action. April 14th. (c) tube broken, as no action (c), (d); April 15th. Action now in (c), but not in (d), so tube broken. April 16th. Action in (a), (b), (c), (d).	
7	(a.) 10 c.c. XXX. distilled water in Roux tube with strip of bright sheet lead. May 23rd, 1894. (b.) Same as (a). (c.) Same as (b), Experiment 1. (d.) " " "	Action began at once in (a), (b). After 1 hour none in (c), (d), so (c) tube broken. May 24th, 1894. Action now in (c), but none in (d), so (d) tube broken. May 25th, 1894. Action now in (a), (b), (c), (d).	
8	(a.) 10 c.c. XXX. distilled water in Roux tube with strip of bright sheet lead. June 2nd, 1894. (b.) Same as (b), Experiment 1. (c.) " " "	Action began at once in (a), and progressively increased. No action in (b) June 5th, 6th, 7th, 8th. (c) tube broken immediately after sealing, but no action June 3rd, 4th, 5th, so fresh lead introduced. By June 7th action in (c).	
9	(a.) 20 c.c. XXX. distilled water in Roux tube with strip of bright sheet lead. June 8th, 1894 (b.) Same as (a) (c.) Same as (b), Experiment 1. (d.) " " " (e.) " " "	Action began at once in (a), (b), and progressively increased in amount. (e): here a slight action was noticed, but it did not increase in amount. No action in (c), (d), so (c) tube broken after 4 hours. Action soon commenced in (c), and was progressive in character.	Not recorded.
10	(a.) 10 c.c. XXX. distilled water in Roux tube with strip of bright sheet lead. June 13th, 1894. (b.) Same as (b), Experiment 1, but hydrogen not admitted. (c.) Same as (b), Experiment 1, but hydrogen not admitted. (d.) Same as (b), Experiment 1. (e.) " " "	Action began at once in (a), and was progressive in character. Very slight action in (b), but not progressive in character. (c) same as (b), so (c) tube broken. Now action in (c) became much greater than in case of (b). Very slight action in (d), but not progressive in character. (e) same as (d), so (e) tube broken. Action now became much greater in (c) than (d).	
11	(a.) 20 c.c. XXX. distilled water in Roux tube with strip of bright sheet lead. June 14th, 1894. (b.) 20 c.c. XXX. distilled water in Roux tube alternately exhausted of air and hydrogen admitted (four times). Strip of bright sheet lead introduced and exhaustion continued for 3 hours, and then tube disconnected and allowed to absorb air.	Action began at once in (a), and was progressive in character. No action in (b) while tube in connection with exhaustion apparatus. After disconnection, however, action began, and progressively increased so that after a few days (a) and (b) showed an apparently equal action.	
12	(a.) 20 c.c. XXX. distilled water in Roux tube with strip of bright sheet lead. January 21st, 1895. (b.) Same as (a). (c.) Same as (b), Experiment 11, but after lead introduced exhaustion continued for half an hour. (d.) Same as (c), but exhaustion continued for one hour.	Action began at once in (a), (b), and was progressive in character. Very slight action in (c), (d), not progressive in character. After half an hour lead removed from (a) and (c), acid added, and lead tested for. After 1 hour (b) and (d) examined in same way.	(a) = 15.00 (b) = 30.00 (c) = 0.25 (d) = 0.50

The above results show very clearly that XXX distilled water capable of eroding lead to a conspicuous extent can, when placed under anaerobic conditions, be prevented from exercising its erosive power owing to the absence of dissolved oxygen. Further, that the subsequent readmission of air restores to the water its erosive ability (Plate XI., Fig. 14). But it is noteworthy that, in some cases, a new piece of lead had to be introduced into the tube of experiment in order to induce action on lead to take place. This leads to the conjecture that *bright* lead, placed for a sufficient length of time under anaerobic, and therefore "erosive-inhibitory" conditions, may pass into a molecular state protecting it to some extent from further erosive action, even when the conditions inhibiting erosion are removed, and notwithstanding the fact of its remaining bright and "uncoated" during the course of the experiment.

In the preceding tables the strong erosive power of XXX distilled water on bright sheet lead has been shown. In contrast to these results, the inertness of the same class of water towards coated lead is shown in Table XIII.

TABLE XIII.

Showing the EFFECT, as regards EROSION of LEAD, of XXX DISTILLED WATER upon LEAD which had previously been SUBMITTED to the ACTION of a HARD LIMESTONE WATER.

[The coating was obtained by leaving bright sheet lead in contact with Settle water—a hard limestone water—overnight; and then washing with distilled water and allowing to dry.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	<p>January 26th, 1895:—</p> <p>(a.) 10 c.c. XXX in test tube with bright sheet lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) 10 c.c. of same water, in test tube with coated lead <math>1 \times \frac{1}{4}</math>".</p> <p>(c.) same as (b).</p> <p>(d.) same as (b) and (c).</p>	<p>In (a) action commenced at once and was progressive in character; no action apparent in (b), (c), (d).</p> <p>January 29th, 1895. Lead removed and acid added.</p>	<p>(a.) 20.0</p> <p>(b.) trace.</p> <p>(c.) trace.</p> <p>(d.) trace.</p>

The table shows that XXX distilled water is unable to display its erosive power if the lead has been allowed previously to acquire a coating of a "plumbo-protective" substance, which was acquired in this case from the contact of *bright* sheet lead with a hard limestone drinking-water.

It has been suggested that, instead of pure lead, alloys of lead and tin should be employed for service pipes to avoid danger from lead poisoning. With the object of discovering how far such alloys would prevent the occurrence of erosion, the experiments set forth in Table XIV. were undertaken.

TABLE XIV.

Showing the EFFECT, as regards EROSION of LEAD, of the ACTION of XXX DISTILLED WATER upon ALLOYS of LEAD and TIN.

[The lead was prepared in the usual manner, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	February 23rd, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but alloy of lead with 2 per cent. tin. (d.) Same as (c). (e.) Same as (a), but alloy of lead with 4 per cent. tin. (f.) Same as (e). (g.) Same as (a), but alloy of lead with 6 per cent. tin. (h.) Same as (g). (i.) Same as (a), but alloy of lead with 10 per cent. tin. (j.) Same as (i).	In (a) and (b) action commenced at once and was progressive in character. Similar action in c, d, i, j. Slight action g, h. No action in e, f. February 25th, 1895. Lead removed and acid added.	(a.) 5.0 (b.) 10.0 (c.) 5.0 (d.) 5.0 (e.) 1.0 (f.) 0.5 (g.) 2.5 (h.) 4. (i.) 5.0 (j.) 5.0
2	March 1st, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but alloy of lead with 2 per cent. tin. (c.) Same as (a), but alloy of lead with 4 per cent. tin. (d.) Same as (a), but alloy of lead with 6 per cent. tin. (e.) Same as (a), but alloy of lead with 10 per cent. tin.	In (a) action commenced at once and was progressive in character. Action in b, d, e. No action in (c). March 4th, 1895. Lead removed and acid added.	(a.) 10.0 (b.) 5.0 (c.) Trace. (d.) 5.0 (e.) 5.0

The results seem to show that an alloy of lead with 4 per cent. of tin almost completely prevents erosion, but that 2 per cent. is not sufficient for this purpose. Curiously, a 4 per cent. alloy seemed to be more satisfactory than a 6 per cent., and much better (according to one experiment) than a 10 per cent. alloy.

By way of determining whether or not the progressive character of erosion is heightened by free exposure of the surface of the water to atmospheric air the experiments given in Table XV. were undertaken.

TABLE XV.

Showing the ACTION, as regards EROSION of LEAD, of XXX DISTILLED WATER upon BRIGHT SHEET LEAD—(a) in Beakers completely filled and exposed to the Air; (b) in Beakers completely filled and the Air excluded.

Experiment.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
2	February 2nd, 1895. Beakers open to the air. (a.) 18 c.c. XXX distilled water in small beaker (completely full) with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a). February 2nd, 1895. As above, but air excluded. (d.) Same as (a), but a piece of glass placed on the top of the beaker and in such a way as to exclude air bubbles. (e.) Same as (d). (f.) Same as (d).	It was noted that the lead salt was deposited in rings—in the case of the exposed beakers (Experiment 1 (a), (b), (c)) the rings were double and near the centre of the beaker—in the case of the covered beakers [Experiment 2 (d), (e), (f)] the rings appeared on the covering glass. February 18th, (a), (d) tested. " 21st, (b), (e) " " 23rd, (c), (f) "	(a.) 25.0 (b.) 20.0 (c.) 50.0 (d.) 10.0 (e.) 5.0 (f.) 15.0

It will be noted that the ultimate amount of lead salt produced by progressive erosion was greatest where the surface of the distilled water was freely exposed to the air.

The following table (Table XVI.) shows, as regards erosion of lead, the influence of the amount of oxygen in XXX distilled water.\*

TABLE XVI.

Showing the INFLUENCE, as regards EROSION of LEAD, of the AMOUNT of OXYGEN in XXX DISTILLED WATER.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000.)
1	February 5th, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first saturated with oxygen.† (c.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c), but the water first saturated with oxygen.	Erosion commenced at once in (a), and subsequently in (c). No action took place in (b), (d) even after several days.	
2	February 6th, 1895:— (a.) Same as (a) Experiment 1. (b.) Same as (b) Experiment 1. (c.) Same as (c) Experiment 1. (d.) Same as (d) Experiment 1.	Same remarks as in Experiment 1.	
3	February 18th, 1895:— (a.) 20 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first saturated with oxygen. (c.) Same as (b). (d.) Same as (b).	Erosion commenced at once in (a) and the action was progressive in character. The other tubes showed no action except for a transitory cloudiness at the very beginning. After 3 hours (a), (b), (c), (d) tested.	(a.) 5·0 (b.) 0·5 (c.) 1·0 (d.) 0·5
4	February 18th, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first saturated with oxygen. (c.) Same as (b), but after saturation with oxygen washed air was aspirated through the water for $\frac{1}{2}$ hour.	Action in both (a) and (c). No action visible in (b). February 19th, (a), (b), (c) tested.	(a.) 10·5 (b.) 1·0 (c.) 7·5
5	February 19th, 1895:— A quantity of XXX distilled water was saturated with oxygen, and some of the same water was exhausted of air. The two were mixed together in the following proportions:— (a.) 8 c.c. XXX exhausted of air with 2 c.c. XXX saturated with oxygen. (b.) 5 c.c. XXX exhausted of air with 5 c.c. XXX saturated with oxygen.	Action took place in (a). No action visible in (b). After 3 hours (a), (b) tested.	(a.) 2·5 (b.) 1·0
6	February 19th, 1895:— A quantity of XXX distilled water saturated with oxygen and a portion kept in (a) a bottle completely filled and stoppered, and another portion kept in (b) a wide mouthed bottle, only partially filled and unstoppered. February 25th:— (a.) 10 c.c. of (a) water in test tube with lead $1 \times \frac{1}{4}$ " and stoppered. (d.) 10 c.c. of (b) water in test tube with lead $1 \times \frac{1}{4}$ " and stoppered.	Action commenced at once in (d). No action was visible in (c). February 26th, (c), (d) tested.	(c.) 0·5 (d.) 10·0

† The oxygen was generated either by heating together  $\text{KClO}_3$  and  $\text{MnO}_2$ , or by adding  $\text{HCl}$  (20 per cent.) to a mixture of  $\text{BaO}_2$  (2 parts) and  $\text{MnO}_2$  (1 part).

\* In experiments 1 and 2 (c) and (d) Shipley water (an acid moorland water) is also considered.



TABLE XVI.—*continued.*

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
7	February 20th, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.), but the water first fully aerated by pouring from one bottle into another many times, and shaking repeatedly.	Action commenced at once in (a) and (b). After 3 hours, (a), (b) tested.	(a.) 10·0 (b.) 10·0
8	February 20th, 1895:— (a.) 1 c.c. XXX distilled water (saturated with oxygen) + 9 c.c. XXX distilled water (saturated with hydrogen) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but 2 c.c. "oxygen water" + 8 c.c. "hydrogen water." (c.) Same as (a), but 5 c.c. "oxygen water" + 5 c.c. "hydrogen water."	Action commenced at once in (a), (b). No action visible in (c). After 5 hours (a), (b), (c) tested.	(a.) 5·0 (b.) 5·0 (c.) 1·0
9	February 25th, 1895:— (a.) 10 c.c. XXX distilled water (fully aerated) + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 8 c.c. XXX distilled water (fully aerated) + 2 c.c. XXX (exhausted of air). (c.) 5 c.c. XXX distilled water (fully aerated) + 5 c.c. XXX (exhausted of air). (d.) 4 c.c. XXX distilled water (fully aerated) + 6 c.c. XXX (exhausted of air). (e.) 3 c.c. XXX distilled water (fully aerated) + 8 c.c. XXX (exhausted of air).	Action in all tubes. Action apparently fairly equal in amount in (b), (c), (d), (e), the greatest action was observed in (a).	
10	March 15th, 1895:— A quantity of XXX distilled water saturated with oxygen and a portion kept in (a) a bottle completely filled and stoppered, and another portion kept in (b) a wide mouthed bottle only partially filled and unstoppered. March 20th:— (c.) 10 c.c. of (a) water in test tube with lead $1 \times \frac{1}{4}$ " and stoppered. (d.) 10 c.c. of (b.) water in test tube with lead $1 \times \frac{1}{4}$ " and stoppered.	Action commenced at once in (d.) No action was visible in (c). March 21st (c), (d), tested.	(c.) 0·0 (d.) 10·0

In the first three experiments it is shown that a water possessed of conspicuous erosive power practically loses that power if the water be *saturated* with oxygen. Experiment 4 shows the same thing, and also that if, after saturation with oxygen, washed atmospheric air be aspirated through the water for half an hour, the ability vigorously to erode lead again shows itself. Experiment 5 shows that a mixture in equal proportions of XXX distilled water (exhausted of air) and XXX distilled water (saturated with oxygen) does not yield a liquid showing much appreciable erosive power; but if the proportion of the former to the latter be as about 4 to 1, instead of as 1 to 1, then decided erosion takes place. Experiments 6 and 10 show that if a quantity of XXX distilled water be saturated with oxygen and divided into two portions, the one part being kept for a few days in a completely filled and stoppered bottle and the other in a partially filled and unstoppered bottle for the same length of time, and then tested for erosion, the former water, displays little or no erosive ability, whilst the latter erodes lead in vigorous fashion. Experiment 7 shows that XXX distilled water, fully oxygenated with atmospheric air by means of pouring and shaking operations, retains all its original power of eroding lead. Experiment 8 shows that a mixture of XXX distilled water saturated with hydrogen and of XXX distilled water saturated with oxygen, allows erosion to take place, provided the proportion of "oxygen water" to "hydrogen water" is sufficiently small; but that if the two artificially prepared waters be mixed together in equal parts then erosion does not take place to any extent. Lastly, Experiment 9 seems to show that a XXX

distilled water need not be by any means fully aerated to allow of erosion taking place.

Table XVII. shows, as regards erosion of lead, the effect of leaving XXX distilled water in contact with lead for varying periods of time.

TABLE XVII.

Showing the EFFECT, as regards EROSION of LEAD, of leaving XXX DISTILLED WATER in CONTACT with LEAD for varying Periods of Time.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Silt (parts per 100,000).
1	March 1st, 1895:— 10 c.c. XXX distilled water (neutral) in each of 12 test tubes (a, b, c, d, e, f, g, h, i, j, k, l) with lead $1 \times \frac{1}{4}$ ".	March 4th, 1895. 4 tubes (a, b, c, d) tested for amount of lead action.  March 7th. 4 tubes (a, f, g, h) tested for amount of lead action.  March 10th. 4 tubes (i, j, k, l) tested for amount of lead action.	a = 10'0 b = 10'0 c = 10'0 d = 10'0 e = 20'0 f = 20'0 g = 20'0 h = 20'0 i = 40'0 j = 30'0 k = 30'0 l = 30'0
2	March 4th, 1895:— 10 c.c. XXX distilled water (neutral) in each of 12 test tubes (a, b, c, d, e, f, g, h, i, j, k, l) with lead $1 \times \frac{1}{4}$ ".	The tubes were tested one each day with the following results:— March 5th (a) - - - " 6th (b) - - - " 7th (c) - - - " 8th (d) - - - " 9th (e) - - - " 10th (f) - - - " 11th (g) - - - " 12th (h) - - - " 13th (i) - - - " 14th (j) - - - " 15th (k) - - - " 16th (l) - - -	a = 10'0 b = 20'0 c = 20'0 d = 25'0 e = 25'0 f = 30'0 g = 30'0 h = 30'0 i = 45'0 j = 40'0 k = 60'0 l = 65'0
3	March 11th, 1895:— 10 c.c. XXX distilled water (neutral) in each of 4 test tubes (a, b, c, d) with lead $1 \times \frac{1}{4}$ ".	The tubes were tested at intervals of 15 minutes. After 15 minutes (a) - - - " 30 " (b) - - - " 45 " (c) - - - " 60 " (d) - - -	a = 2'0 b = 3'0 c = 3'5 d = 5'0
4	March 11th, 1895:— 10 c.c. XXX distilled water (neutral) in each of 4 test tubes (a, b, c, d) with lead $1 \times \frac{1}{4}$ ".	The tubes were tested at intervals of 1 hour. After 1 hour (a) - - - " 2 hours (b) - - - " 3 " (c) - - - " 4 " (d) - - -	a = 5'0 b = 7'5 c = 7'5 d = 8'8
5	March 15th, 1895:— 10 c.c. XXX distilled water (neutral) in each of 4 test tubes (a, b, c, d) with lead $1 \times \frac{1}{4}$ ".	The tubes were tested at intervals of 15 minutes. After 15 minutes (a) - - - " 30 " (b) - - - " 45 " (c) - - - " 60 " (d) - - -	a = 2'5 b = 3'0 c = 3'0 d = 4'0
6	March 18th, 1895:— 10 c.c. XXX distilled water (neutral) in each of 12 test tubes (a, b, c, d, e, f, g, h, i, j, k, l) with lead $1 \times \frac{1}{4}$ ".	The tubes were tested at intervals of 1 week. March 25th (a) - - - April 1st (b) - - - " 8th (c) - - - " 15th (d) - - - " 22nd (e) - - - " 29th (f) - - - May 6th (g) - - - " 13th (h) - - - " 20th (i) - - - " 27th (j) - - - June 3rd (k) - - - " 10th (l) - - -	a = 25'0 b = 40'0 c = 60'0 d = 80'0 e = 120'0 f = 120'0 g = 120'0 h = 140'0 i = 160'0 j = 160'0 k = 180'0 l = 180'0

The results clearly show how dangerous this property of erosion may really be, since the action on lead is progressive. Experiments 3 and 5 show that, although the amount of lead compound formed by erosion be not doubled when the duration of contact is 30 minutes, as compared with 15 minutes, nevertheless, it is increased two-fold if the exposure be about one hour. Experiment 4 shows that two hours' as compared with one hour's contact may involve a 50 per cent. increase in the amount of lead compound formed. Experiment 2 shows that two days' as compared with one day's contact sufficed to cause 100 per cent. increase. Experiment 6 shows that two weeks as compared with one week may mean almost a doubling of the quantity of lead eroded.

In Table XVIII. the result as regards erosion of lead of keeping the experimental tubes exposed to light and protected from light are given.

TABLE XVIII.

Showing the ACTION, as regards EROSION of LEAD, of XXX DISTILLED WATER upon LEAD—(a) in the PRESENCE of LIGHT, (b) in the ABSENCE of LIGHT.

[Bright sheet lead was used, and pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	February 26th, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (c.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (d.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (e.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (f.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (g.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (h.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (i.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (j.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (a), (b), (c), (d), (e) exposed to light. (f), (g), (h), (i), (j) kept in darkness.	Feb. 28th, (a), (f) tested Mar. 1st, (b), (g) " " 5th, (c), (h) " " 6th, (d), (i) " " 7th, (e), (j) "	(a.) 10·0 (b.) 13·5 (c.) 15·0 (d.) 15·0 (e.) 17·0 (f.) 10·0 (g.) 12·5 (h.) 10·0 (i.) 15·0 (j.) 17·0
2	March 15th, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (c.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (d.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (e.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (f.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (g.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (h.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (i.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (j.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ " (a), (b), (c), (d), (e) exposed to light. (f), (g), (h), (i), (j) kept in darkness.	Mar. 16th, (a), (f) tested " 17th, (b), (g) " " 18th, (c), (h) " " 19th, (d), (i) " " 20th, (e), (j) "	(a.) 10·0 (b.) 10·0 (c.) 10·0 (d.) 15·0 (e.) 15·0 (f.) 10·0 (g.) 10·0 (h.) 10·0 (i.) 10·0 (j.) 20·0

TABLE XVIII.—*continued.*

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
3	January 28th, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (h.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (i.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (j.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (a), (b), (c), (d), (e) exposed to light. (f), (g), (h), (i), (j) kept in darkness.	Feb. 1st, (a), (b), (c), (d), (e), (f), (g), (h), (i), (j) tested.	(a.) 25.0 (b.) 20.0 (c.) 20.0 (d.) 20.0 (e.) 20.0 (f.) 15.0 (g.) 15.0 (h.) 15.0 (i.) 20.0 (j.) 10.0
4	February 1st, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (h.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (i.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (j.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (a), (b), (c), (d), (e) exposed to light. (f), (g), (h), (i), (j) kept in darkness.	Feb. 4th, (a), (f) tested " 5th, (b), (g) " " 6th, (c), (h) " " 7th, (d), (i) " " 8th, (e), (j) "	(a.) 15.0 (b.) 20.0 (c.) 15.0 (d.) 30.0 (e.) 30.0 (f.) 10.0 (g.) 15.0 (h.) 10.0 (i.) 25.0 (j.) 35.0

It will be seen that the tubes exposed to light showed, on the average, a slightly greater action than those kept in darkness, but the difference was not well marked.

In Table XIX. the results, as regards erosion of lead of varying the extent of lead surface are set forth.

TABLE XIX.

Showing the RESULT, as regards EROSION of LEAD, of varying the EXTENT of LEAD SURFACE\* exposed to the Action of XXX DISTILLED WATER.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ",  $1 \times \frac{1}{4}$ ",  $1 \times \frac{1}{8}$ ") completely submerged.]

Experiment.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
1	February 1st, 1895:—		
A	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{2}$ ".	The pieces of lead in all the experiments were placed upright, the only difference being that the lead in experiment 2 was half the width of the lead in experiment 1, and the lead in experiment 3 was half the width of the lead in experiment 2. The object of the experiment was to determine whether the erosion was proportional to the lead surface exposed.	A 20·0
B	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ".		B 20·0
C	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{8}$ ".		C 20·0
D	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ".		D 20·0
2	February 1st, 1895:—		
E	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{2}$ ".	February 5th, 1895. Distinct action in all the tubes. Action in A, B, C, D, greater than in E, F, G, H. Action in E, F, G, H, comparable to action in I, J, K, L.	E 15·0
F	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ".		F 15·0
G	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{8}$ ".		G 15·0
H	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ".		H 15·0
3	February 1st, 1895:—		
I	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{2}$ ".	February 5th. Lead removed, acid added to contents of tubes, and amount of lead estimated.	I 15·0
J	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ".		J 15·0
K	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{8}$ ".		K 15·0
L	10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ".		L 15·0

\* The thickness of the sheet lead used was in every case as nearly as possible uniform.

It will be noted that the strips of bright sheet lead were all completely submerged and all 1 inch in length. The width varied, however, from  $\frac{1}{2}$  inch to  $\frac{1}{4}$  inch to  $\frac{1}{8}$  inch. Such variations did not suffice to bring out to any appreciable extent a difference in the amount of lead compound formed.

Attention may now be directed to certain salts which, in the proportion of 0·1 per cent. were found to have a strong inhibitory action as regards erosion. These results are shown in the following three tables (Tables XX., XXI., and XXII.):—

TABLE XX.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of AMMONIUM CHLORIDE ( $\text{NH}_4\text{Cl}$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	August 20th, 1894 :— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0·1 per cent. $\text{NH}_4\text{Cl}$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character. In (b) very slight action, no progressive increase.	No record.
2	February 7th, 1895 :— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0·1 per cent. $\text{NH}_4\text{Cl}$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual. No apparent action in (b). February 9th, 1895. Lead removed and acid added.	(a.) 10·0 (b.) 1·0
3	February 11th, 1895 :— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0·1 per cent. $\text{NH}_4\text{Cl}$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual. No apparent action in (b), the lead being well coated, minute crystals adhering. February 13th, 1895. Lead removed and acid added.	(a.) 20·0 (b.) 2·5

TABLE XXI.

Showing the EFFECT, as regard EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of MAGNESIUM SULPHATE ( $\text{MgSO}_4$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	October 17th, 1894 :— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0·1 per cent. $\text{MgSO}_4$ , in test tube with lead $1 \times \frac{1}{4}$ " (c.) same as (b).	In (a) action commenced at once and was progressive in character; practically no action in (b) and (c).	No record.
2	February 7th, 1895 :— (a.) 10 c.c. XXX in test tube, with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0·1 per cent. $\text{MgSO}_4$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual, slight action in (b). February 9th, 1895. Lead removed and acid added.	(a.) 10·0 (b.) 2·5
3	February 11th, 1895 :— (a.) 10 c.c. XXX in test tubes with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0·1 per cent. $\text{MgSO}_4$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual; slight action in (b). February 13th, 1895. Lead removed and acid added.	(a.) 20·0 (b.) 2·0

TABLE XXII.

Showing the EFFECT, as regards EROSION OF LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of SODIUM CHLORIDE ( $\text{NaCl}$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	August 20th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaCl}$ , in test tube with lead $1 \times \frac{1}{2}$ ".	In (a) action commenced at once and was progressive in character. No action in (b).	Not recorded.
2	February 7th, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaCl}$ , in test tube with lead $1 \times \frac{1}{2}$ ".	In (a) action as usual. No apparent action in (b). February 9th, 1895. Lead removed and acid added.	(a.) 10.0 (b.) Trace.
3	February 11th, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaCl}$ , in test tube with lead $1 \times \frac{1}{2}$ ".	In (a) action as usual. No apparent action in (b). February 13th, 1895. Lead removed and acid added.	(a.) 20.0 (b.) Trace.

It will be seen from the above tables that ammonium chloride, magnesium sulphate, and sodium chloride acted as strong "plumbo-protective" substances.

Calcium sulphate (saturated solution) also acted as an inhibitory agent, but not to nearly the same extent. The results are given in the following table (Table XXIII.) :—

TABLE XXIII.

Showing the EFFECT, as regards EROSION OF LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of CALCIUM SULPHATE ( $\text{CaSO}_4$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Salt (parts per 100,000).
1	August 20th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 10 c.c. of same water, saturated with $\text{CaSO}_4$ , in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral "	Action commenced at once and was progressive in character, but was not so decided in (b) as in (a).	No record.
2	August 20th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 1 c.c. of saturated solution $\text{CaSO}_4$ added to 10 c.c. of same water, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral "	Action commenced at once and was progressive in character, but was not so decided in (b) as in (a).	No record.

TABLE XXIII.—*continued.*

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Salt (parts per 100,000).
3	December 14th, 1894:— (a.) 10 c.c. XXX shaken and filtered, in test tube with lead $1 \times \frac{1}{4}$ ". (b) 10 c.c. of same water, saturated with $\text{CaSO}_4$ , shaken and filtered, in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral "	Action commenced at once and was progressive in character, but was not so decided in (b) as in (a). December 17th 1894. Lead removed and acid added.	(a.) 15.0 (b.) 4.0
4	January 17th, 1895:— (a.) 10 c.c. XXX shaken and filtered, in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. of same water + 0.1 per cent. $\text{CaSO}_4$ , shaken and filtered, in test tube with lead $1 \times \frac{1}{4}$ ". (d) Same as (c).	Neutral " " "	Action commenced at once and was progressive in character, but was not so decided in (c) and (d) as in (a) and (b). (a) and (c) tested Jan. 18th; (b) and (d) tested Jan. 22nd.	(a.) 15.0 (b.) 30.0 (c.) 5.0 (d.) 1

The following salts in the proportion of 0.1 per cent. gave usually the appearance of increased erosive action, viz., sodium nitrate, sodium nitrite, potassium nitrate, and potassium nitrite. But on estimating the amount of lead compound formed no difference could be observed between the waters treated with these salts and the control experiments. Indeed, in the case of a single experiment with potassium nitrite, a decrease of action was noted. These results are shown in the following tables (Tables XXIV., XXV., XXVI., and XXVII.).

TABLE XXIV.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of SODIUM NITRATE ( $\text{NaNO}_3$ ).

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	October 17th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaNO}_3$ , in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water, with 0.01 per cent. $\text{NaNO}_3$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character; in (b) and (c) action was apparently greater than in case of (a).	No record.
2	October 28th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaNO}_3$ , in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water, with 0.01 per cent. $\text{NaNO}_3$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual; action was apparently greater in (b) and (c) than in case of (a). October 28th, 1894. Lead removed and acid added.	(a.) 2.5 (b.) 2.5 (c.) 2.5
3	February 12th, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaNO}_3$ , in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual, action apparently greater in (b) than in case of (a). February 13th, 1894. Lead removed and acid added.	(a.) 10.0 (b.) 10.0



TABLE XXV.

Showing the ACTION, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of SODIUM NITRITE ( $\text{NaNO}_2$ ).

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	October 17th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water with 0.1 per cent. $\text{NaNO}_2$ in test tube with lead $1 \times \frac{1}{4}$ " (c.) same as (b.).	In (a) action commenced at once and was progressive in character; action also in (b) and (c), and apparently greater than in case of (a).	No record.
2	October 26th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaNO}_2$ in test tube with lead $1 \times \frac{1}{4}$ " (c.) 10 c.c. of same water, with 0.01 per cent. $\text{NaNO}_2$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual; action apparently greater in (b) and (c) than in case of (a). October 28th, 1894. Lead removed and acid added.	(a.) 2.5 (b.) 2.5 (c.) 2.5
3	February 13th, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NaNO}_2$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual; action also in (b). February 14th, 1895. Lead removed and acid added.	(a.) 15.0 (b.) 15.0

TABLE XXVI.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of POTASSIUM NITRATE ( $\text{KNO}_3$ ).

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	October 19th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0.1 per cent. $\text{KNO}_3$ in test tube, with lead $1 \times \frac{1}{4}$ " (c.) Same as (b.).	In (a) action commenced at once and was progressive in character. Action apparently greater in (b) and (c) than in case of (a).	No record.
2	February 12th, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ " (b.) 10 c.c. of same water, with 0.1 per cent. $\text{KNO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual. Action apparently greater in (b) than in case of (a). February 13th, 1895. Lead removed, and acid added.	(a.) 10.0 (b.) 10.0

TABLE XXVII.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of POTASSIUM NITRITE ( $\text{KNO}_2$ ).

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	October 19th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{KNO}_2$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) Same as (b.).	In (a) action commenced at once, and was progressive in character. Action also in (b) and (c).	No record.
2	February 13th, 1895:— (a.) 10 c.c. XXX in test tube, with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{KNO}_2$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual. Action also in (b). February 14th, 1895, lead removed, acid added, and lead estimated.	(a.) 15.0 (b.) 5.0

Ammonium nitrate, on the other hand, in the proportion of 0.1 per cent., brought about a marked increase of erosion. These results are shown in the table (Table XXVIII.) which follows.

TABLE XXVIII.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of AMMONIUM NITRATE ( $\text{NH}_4\text{NO}_3$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ " ) completely submerged.]

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Salt (parts per 100,000).
1	August 20th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water + 0.1 per cent. $\text{NH}_4\text{NO}_3$ in test tube, with lead $1 \times \frac{1}{4}$ ".	Neutral "	(a.) Action commenced at once and was progressive in character; action in (b), however, was considerably greater than in case of (a).	No record.
2	October 17th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water + 0.1 per cent. $\text{NH}_4\text{NO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) Same as (b.).	Neutral " "	(a.) Action commenced at once and was progressive in character; action in (b) and (c), however, was considerably greater than in case of (a).	No record.
3	October 24th, 1894:— (a.) 10 c.c. XXX in test tube, with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water + 0.01 per cent. $\text{NH}_4\text{NO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral " "	(a.) Action commenced at once and was progressive in character; action in (b) and (c), however, was considerably greater proportionally than in case of (a). October 28th. Lead removed and acid added.	(a.) 2.5 (b.) 20.0 (c.) 5.0
4	February 12th, 1895:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\text{NH}_4\text{NO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral "	(a.) Action commenced at once and was progressive in character. (b.) Very great action, apparently considerably greater than in case of (a). February 13th, 1895. Lead removed and acid added.	(a.) 10.0 (b.) 75.0

In the following table (Table XXIX.) the effect is shown, as regards erosion of lead, of shaking XXX distilled water with silica, and then filtering it.

TABLE XXIX.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of SILICA ( $\text{SiO}_2$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ " ) completely submerged.]

No.	Description of Experiment.	Reaction.	Remarks.	Total Lead Salt (parts per 100,000.)
1	October 30th, 1894:— (a.) 10 c.c. XXX, shaken and filtered, in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 10 c.c. of same water + 0.1 per cent. $\text{SiO}_2$ , shaken and filtered, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral "	Action commenced at once and was progressive in character. Action in (b) same as that in (a.) October, 31st, 1894. Lead removed and acid added.	(a.) 15.0 (b.) 15.0
2	November 12th, 1894:— (a.) 10 c.c. XXX, shaken and filtered, in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 10 c.c. of same water + 0.1 per cent. $\text{SiO}_2$ , shaken and filtered, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral "	Action commenced at once and was progressive in character. Action in (b) same as that in (a.) November 14th, 1894. Lead removed and acid added.	(a.) 30.0 (b.) 30.0
3	December 14th, 1894:— (a.) 10 c.c. XXX, shaken and filtered, in test tube with lead $1 \times \frac{1}{2}$ ". (b.) 10 c.c. of same water + 0.1 per cent. $\text{SiO}_2$ , shaken and filtered, in test tube with lead $1 \times \frac{1}{2}$ ".	Neutral "	Action commenced at once and was progressive in character. Action in (b) same as that in (a.) December 17th, 1894. Lead removed and acid added.	(a.) 15.0 (b.) 15.0

Silica is insoluble, or relatively so; nevertheless, it was thought desirable to carry out the above experiments to see whether, under the conditions of the experiment, any differences as regards erosive ability could be detected. As might have been anticipated no alteration in the erosive power of the water was produced by contact with the silica.

The effects, as regards erosion of lead, of the addition to XXX distilled water of acids (mineral acids and water containing dissolved carbonic acid) are shown in the following tables (Tables XXX. and XXXI.).

TABLE XXX.

Showing the EFFECT, as regards EROSION of LEAD, of adding MEASURED QUANTITIES of SULPHURIC ACID ( $H_2SO_4$ ), HYDROCHLORIC ACID, (HCl), and NITRIC ACID ( $HNO_3$ ) to XXX DISTILLED WATER.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ "') completely submerged.]

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
1	February 16th, 1895:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 1 per cent. $\frac{10}{10}$ $H_2SO_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + 0.1 per cent. $\frac{10}{10}$ $H_2SO_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + 0.01 per cent. $\frac{10}{10}$ $H_2SO_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + 1 per cent. $\frac{10}{10}$ HCl in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + 0.1 per cent. $\frac{10}{10}$ HCl in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. XXX distilled water + 0.01 per cent. $\frac{10}{10}$ HCl in test tube with lead $1 \times \frac{1}{4}$ ". (h.) 10 c.c. XXX distilled water + 1 per cent. $\frac{10}{10}$ $HNO_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (i.) 10 c.c. XXX distilled water + 0.1 per cent. $\frac{10}{10}$ $HNO_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (j.) 10 c.c. XXX distilled water + 0.01 per cent. $\frac{10}{10}$ $HNO_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	Erosion began at once in (a), later in (d), (g), (j), still later in (c), (f), (i), last of all in (b), (e), (h). February 25th, 1895. Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 30.0 (b.) 10.0 (c.) 25.0 (d.) 30.0 (e.) 20.0 (f.) 20.0 (g.) 30.0 (h.) 25.0 (i.) 25.0 (j.) 20.0
2	April 12th, 1895:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 1 per cent. $\frac{10}{10}$ $H_2SO_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + 0.1 per cent. $\frac{10}{10}$ $H_2SO_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + 0.01 per cent. $\frac{10}{10}$ $H_2SO_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + 1 per cent. $\frac{10}{10}$ HCl in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + 0.1 per cent. $\frac{10}{10}$ HCl in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. XXX distilled water + 0.01 per cent. $\frac{10}{10}$ HCl in test tube with lead $1 \times \frac{1}{4}$ ". (h.) 10 c.c. XXX distilled water + 1 per cent. $\frac{10}{10}$ $HNO_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (i.) 10 c.c. XXX distilled water + 0.1 per cent. $\frac{10}{10}$ $HNO_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (j.) 10 c.c. XXX distilled water + 0.01 per cent. $\frac{10}{10}$ $HNO_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	April 20th, 1895. Distinct action in all the tubes. Action apparently least in (b), (e), (h). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 40.0 (b.) 15.0 (c.) 30.0 (d.) 30.0 (e.) 20.0 (f.) 30.0 (g.) 30.0 (h.) 30.0 (i.) 30.0 (j.) 30.0

TABLE XXX.—*continued.*

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
3	October 18th, 1894:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 0.1 per cent. $\text{H}_2\text{SO}_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + 0.01 per cent. $\text{H}_2\text{SO}_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + 0.1 per cent. $\text{HCl}$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + 0.01 per cent. $\text{HCl}$ in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + 0.1 per cent. $\text{HNO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. XXX distilled water + 0.01 per cent. $\text{HNO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	October 19th. No action visible in (b), (d), (f). Action distinct in (a), (c), (e), (g). October 22nd. No action visible in (b), (d), (f). (a), (c), (e), (g) tested. By October 26th action visible in (b), (d), (f). (b), (d), (f) tested.	(a.) 40.0 (b.) 20.0 (c.) 30.0 (d.) 30.0 (e.) 35.0 (f.) 30.0 (g.) 35.0
4	May 31st, 1894:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 1 per cent. $\text{H}_2\text{SO}_4$ in test tube with lead $1 \times \frac{1}{4}$ ".	Action commenced at once in (a), and was progressive in character. June 5th. No action visible in (b), decided action in (a). Subsequently, however erosion distinct in (b).	

TABLE XXXI.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of DISTILLED WATER saturated with  $\text{CO}_2$ .

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

No.	Description of the Experiment.	Remarks.
1	January 23rd, 1895:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 0.05 c.c.* $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + 0.1 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + 0.2 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + 0.3 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + 0.4 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (g.) 5 c.c. XXX distilled water + 5 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ".	Erosion commenced at once in (a), (b), (c), (d), (e), (f), but the lead compound was dissolved as soon as formed in the case of (f), (e), (d), and also to a certain extent in (c) and (b). No erosion visible in (g). After one hour (a), (b) alone showed erosion, the pieces of lead in all the other tubes coated except (g), which remained bright. By January 26th, however, (f) showed distinct erosion, while all the rest remained clear except (a) and (b). By February 2nd, great action noted in (g), and traces of action in (c), (d), (e). By February 25th very marked action in (a), (b) and in (f), (g); very little erosion in (c), (d), (e), the lead being fairly well coated.
2	February 2nd, 1895:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 0.05 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + 0.1 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + 0.2 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ".	Erosion commenced at once in (a), (b), (c), (d), (e), (f), but the lead compound seemed to be dissolved as soon as formed, so that at end of one hour (a), (b), (c) alone showed distinct action. No action in (g). By February 25th action in all but (d), the lead being fairly well coated.

\*  $\text{H}_2\text{CO}_3$  solution obtained by saturating distilled water with  $\text{CO}_2$ .

TABLE XXXI.—*continued.*

No.	Description of the Experiment.	Remarks.
2	February 2nd, 1895— <i>cont.</i> (e.) 10 c.c. XXX distilled water + 0.3 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + 0.4 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ". (g.) 5 c.c. XXX distilled water + 5 c.c. $\text{H}_2\text{CO}_3$ solution with lead $1 \times \frac{1}{4}$ ".	
3	February 2nd, 1895:— (a.) (b.) (c.) (d.) (e.) (f.) (g.)	Erosion commenced at once in all but (g), but the lead compound appeared to be dissolved as soon as formed, so that at end of one hour action apparent only in (a), (b), (c). February 25th action in (a), (b), (c). Slight action only in (d), the lead being fairly well coated. In (e) and (f) lead coating brick red in colour.

As regards the mineral acids ( $\text{H}_2\text{SO}_4$ ,  $\text{HCl}$ , and  $\text{HNO}_3$ ) the results in general seemed to show that their action was rather in the direction of delaying erosion than of absolutely preventing it, or even of greatly diminishing the degree of action. Thus the addition of 1.0 per cent. of a decinormal solution of the mineral acids usually inhibited erosion more than 0.1 per cent., and 0.1 per cent. commonly more than 0.01 per cent.

As regards the addition of measured quantities of carbonic acid water (obtained by saturating distilled water with carbonic acid) to the distilled water (Table XXXI.), the results seemed to show that very small quantities did not inhibit erosion, but that the lead compound, as soon as it was formed, became dissolved in the water up to a certain point: afterwards the action proceeded in the usual manner. Slightly larger amounts (about 0.2 c.c.  $\text{H}_2\text{CO}_3$  solution in 10 c.c. XXX water) appeared to inhibit erosion by leading to the formation of a protective coating on the surface of the lead. A large proportion of carbonic acid water in two out of the three experiments delayed, but did not prevent, erosion.

It is convenient next to consider the effect, as regards erosion of lead, of the addition to XXX distilled water of measured quantities of alkalis, namely, lime water (Table XXXII.), sodium carbonate (Table XXXIII.), and sodium bicarbonate (Table XXXIV.).

TABLE XXXII.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of LIME WATER ( $\text{CaO}$ ,  $\text{H}_2\text{O}$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	November 26th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. of same water, with $\text{CaO}$ , $\text{H}_2\text{O}$ equivalent in neutralising power to 0.24 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ —in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c).	In (a) and (b) action commenced at once and was progressive in character. Action also in (c), (d); (e), (f); (g), (h). November 27th 1894. Lead removed and acid added.	(a.) 10.0 (b.) 10.0 (c.) 10.0   (d.) 10.0

TABLE XXXII.—continued.

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	<p>November 26th, 1894—cont.</p> <p>(e.) 10 c.c. of same water, with CaO, H<sub>2</sub>O equivalent in neutralising power to 0.6 per cent. <math>\frac{N}{10}</math> Na<sub>2</sub>CO<sub>3</sub>—in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(f.) Same as (e).</p> <p>(g.) 10 c.c. of same water, with CaO, H<sub>2</sub>O equivalent in neutralising power to 0.9 per cent. <math>\frac{N}{10}</math> Na<sub>2</sub>CO<sub>3</sub>—in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(h.) Same as (g).</p> <p>November 27th, 1894:—</p> <p>(a.) 10 c.c. XXX in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(b.) Same as (a).</p> <p>(c.) 10 c.c. of same water, with CaO, H<sub>2</sub>O equivalent in neutralising power to 1.2 per cent. <math>\frac{N}{10}</math> Na<sub>2</sub>CO<sub>3</sub>—in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(d.) Same as (c).</p> <p>(e.) 10 c.c. of same water, with CaO, H<sub>2</sub>O equivalent in neutralising power to 1.5 per cent. <math>\frac{N}{10}</math> Na<sub>2</sub>CO<sub>3</sub>—in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(f.) Same as (e).</p> <p>(g.) 10 c.c. of same water, with CaO, H<sub>2</sub>O equivalent in neutralising power to 3.0 per cent. <math>\frac{N}{10}</math> Na<sub>2</sub>CO<sub>3</sub>—in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(h.) Same as (g).</p> <p>January 26th, 1895:—</p> <p>(a.) 10 c.c. XXX in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(b.) 10 c.c. of same water, with 0.2 per cent. saturated solution of CaO, in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(c.) 10 c.c. of same water, with 0.4 per cent. saturated solution of CaO, in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(d.) 10 c.c. of same water, with 0.8 per cent. saturated solution of CaO, in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(e.) 10 c.c. of same water, with 1.2 per cent. saturated solution of CaO, in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(f.) 10 c.c. of same water, with 1.6 per cent. saturated solution of CaO, in test tube with lead 1×<math>\frac{1}{4}</math>".</p> <p>(g.) 10 c.c. of same water, with 2.0 per cent. saturated solution of CaO, in test tube with lead 1×<math>\frac{1}{4}</math>".</p>	<p>In (a) and (b) action commenced at once, and was progressive in character. Action also in (c), (d); (e), (f).</p> <p>No apparent action in (g), (h).</p> <p>November 28th 1894. Lead removed and acid added.</p> <p>In (a) action commenced at once, and was progressive in character. Action also in (b), (c), (d), (e), (f).</p> <p>No action in (g).</p> <p>January 26th 1895. Lead removed and acid added.</p>	<p>(e.) 10.0</p> <p>(f.) 10.0</p> <p>(g.) 10.0</p> <p>(h.) 10.0</p> <p>(a.) 10.0</p> <p>(b.) 10.0</p> <p>(c.) 10.0</p> <p>(d.) 10.0</p> <p>(e.) 10.0</p> <p>(f.) 10.0</p> <p>(g.) 5.0</p> <p>(h.) 3.0</p> <p>(a.) 10.0</p> <p>(b.) 10.0</p> <p>(c.) 10.0</p> <p>(d.) 10.0</p> <p>(e.) 10.0</p> <p>(f.) 10.0</p> <p>(g.) Trace.</p>

The lead remained bright even when lime water was present in considerable amount.

TABLE XXXIII.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of SODIUM CARBONATE (Na<sub>2</sub>CO<sub>3</sub>).  
 [Bright sheet lead was used, and the pieces (1× $\frac{1}{2}$ " completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000.)
1	<p>March 29th, 1894:—</p> <p>10 c.c. XXX with 1 per cent. <math>\frac{N}{10}</math> Na<sub>2</sub>CO<sub>3</sub> in test tubes—(a) (b), and (c)—with lead 1×<math>\frac{1}{4}</math>".</p>	<p>No action in (a), (b), or (c), but a bluish white film formed on metal.</p>	<p>(a.) (b.) (c.) 0.0; 0.0; 0.0</p>

TABLE XXXIII.—continued.

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
2	April 4th, 1894:— 10 c.c. XXX with 1 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ in 3 test tubes—(a), (b), and (c)—with lead $1 \times \frac{1}{4}$ ".	No action in (a), (b), or (c), but a bluish-white film formed on metal.	(a.) (b.) (c.) 0·0; 0·0; 0·0
3	May 31st, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water with 1 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character; in (b) no action.	
4	August 20th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·1 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character; in (b) no action, but firmly-adherent film formed on metal.	
5	September 24th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character; in (b) no action. Lead renewed in (b) on September 28th and 29th, 1894; still no action in (b) on October 1st, 1894.	
6	September 30th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·03 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water, with 0·2 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water, with 0·5 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a), (b), (c), action commenced at once and was progressive in character; in (d) no action. Lead renewed in (d) at intervals— October 1st, 1894, once; October 2nd, twice; October 4th, 1894, thrice; October 5th, thrice; October 6th, 1894, twice. October 7th, 1894, still no action in (d).	
7	October 6th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·12 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (c.) 10 c.c. of same water, with 0·18 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (d.) 10 c.c. of same water, with 0·24 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (e.) 10 c.c. of same water, with 0·30 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (f.) 10 c.c. of same water, with 0·36 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (g.) 10 c.c. of same water, with 0·42 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (h.) 10 c.c. of same water, with 0·48 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (i.) 10 c.c. of same water, with 0·54 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	October 7th, 1894. Action in (a) as usual; action also in (b), (c), (d), (e), but lead salt produced was of more curdy and less milky appearance than in case of (a). Slight action in (f) and (g); practically none in (h) and (i). October 10th, 1894. Same remarks.	
8	November 26th, 1894:— (a.) and (b.) 10 c.c. XXX in test tubes with lead $1 \times \frac{1}{4}$ ". (c.) and (d.) 10 c.c. of same water, with 0·24 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . (e.) and (f.) 10 c.c. of same water, with 0·6 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	Action in (a) and (b) as usual; also action in (c) and (d) as in Experiment 7. No action in (e) and (f). November 27th, 1894. Lead removed and acid added.	(a.) } 10·0 (b.) } (c.) } 10·0 (d.) } (e.) } traces. (f.) }
9	November 29th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·2 per cent. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	Action in (b) as usual. Very distinct action in (b), but none in (c), (d), (e).	(a.) 20·0 (b.) 10·0

Not recorded.



TABLE XXXII.—*continued.*

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
9	November 29th, 1894— <i>cont.</i> (c.) 10 c.c. of same water, with 0·4 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . (d.) 10 c.c. of same water, with 0·6 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . (e.) 10 c.c. of same water, with 0·8 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .	November 30th, 1894. Lead removed and acid added.	(c.) 0·5 (d.) 0·5 (e.) 0·5
10	November 30th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·1 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . (c.) 10 c.c. of same water, with 0·2 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . (d.) 10 c.c. of same water, with 0·3 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . (e.) 10 c.c. of same water, with 0·4 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .	Action in (a) as usual. Very distinct action also in (b) and (c). No apparent action in (d) or (e). December 1st, 1894. Lead removed and acid added.	(a.) 20·0 (b.) 10·0 (c.) 12·0 (d.) 0·5 (e.) 1·0

TABLE XXXIV.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of SODIUM BICARBONATE ( $\text{NaHCO}_3$ ).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	November 29th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·2 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water, with 0·4 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water, with 0·6 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. of same water, with 0·8 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character. Very slight action in (b). No action in c, d, e. November 30th, 1894. Lead removed and acid added. In the case of c, d, e, the lead was coated with a bluish-white firmly-adherent film.	(a.) 20·0 (b.) 0·5 (c.) 0·0 (d.) 0·0 (e.) 0·0
2	November 30th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0·1 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water, with 0·2 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water, with 0·3 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. of same water, with 0·4 per cent. $\frac{1}{10}$ $\text{NaHCO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character. Action also in (b) and (c). No action apparently in (d) or (e). December 1st, 1894. Lead removed and acid added. In the case of (d) and (e) the lead was coated with a bluish-white firmly-adherent film.	(a.) 20·0 (b.) 10·0 (c.) 10·0 (d.) 0·5 (e.) 0·0

TABLE XXXIV.—*continued.*

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
3	November 13th, 1894.— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. $\frac{1}{10}$ NaHCO <sub>3</sub> in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character. No action in (b), but lead was coated with a bluish-white firmly-adherent film. November 14th, 1894. Lead removed and acid added.	(a.) 30.0 (b.) Trace.

As regard lime water, it is apparent from the result shown in Table XXXII., that relatively large amounts of this substance are needed to inhibit to any appreciable degree the erosive action of XXX distilled water. As much as 1.6 per cent. of a saturated solution was inoperative and, in all the experiments, coating of the lead was either absent or unsatisfactory in character.

Sodium carbonate (Table XXXIII.), on the contrary, was most efficacious, small quantities only being required to coat the metal with a firmly adherent blush-white film, which prevented erosion from taking place (Plate X., Fig. 13D). The amount required naturally varied with the different samples of XXX distilled water; but, speaking in general terms, it may be said that 0.5 per cent. of a decinormal solution was in excess of the quantity actually needed. It will be noted that in Experiment 6, this amount not only inhibited erosion, but that renewal of the pieces of lead, at intervals, when they had become well coated, on no less than 11 occasions failed to initiate any action or to use up the "plumbo-protective" qualities of the sodium carbonate.

Very similar results were obtained with sodium bicarbonate (Table XXXIV.), which substance in minimal amount also coated the lead with a bluish-white firmly-adherent film.

Lastly, there remains for consideration the effect as regards erosion of lead of adding to XXX distilled water measured quantities of an artificially prepared calcium bicarbonate water and a natural water rich in this substance (Settle Public Water Supply—a hard limestone water). These results are shown in the following tables (Tables XXXV. and XXXVI.).

TABLE XXXV.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of CALCIUM BICARBONATE (CaCO<sub>3</sub>, H<sub>2</sub>CO<sub>3</sub>).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	January 23rd, 1895.— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.5 per cent. calcium bicarbonate solution, in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once, and was progressive in character. Decided action also in (b), (c), (d), (e), (f), (g).	(a.) 10.0 (b.) 10.0

\* Distilled water was saturated with CO<sub>2</sub> and allowed to filter repeatedly through Iceland spar until it ceased to show an acid reaction with lacmoid.

TABLE XXXV.—continued.

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	January 23rd, 1895—cont. (c.) 10 c.c. of same water, with 1.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water, with 2.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. of same water, with 3.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. of same water, with 4.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. of same water, with 5.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (h.) 10 c.c. of same water with 10 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (i.) 10 c.c. of same water, with 20 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ".	No action in (h) and (i). January 23rd, 1895, lead removed and acid added. In the case of (h) and (i) the lead was coated with a bluish-white firmly-adherent film.	(c.) 10.0 (d.) 10.0 (e.) 10.0 (f.) 5.0 (g.) 10.0 (h.) 1.0 (i.) 0.0
2	February 2nd, 1895:— (a.) 10 c.c. XXX, in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 5.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water, with 10.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water, with 20.0 per cent. calcium bicarbonate, in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action as usual. No action in (b), (c), (d). February 3rd, 1895, Lead removed and acid added. In the case of (b), (c), and (d) the lead was coated with a bluish-white firmly-adherent film.	(a.) 10.0 (b.) 0.0 (c.) 0.0 (d.) 0.0

\* Excess of crushed Iceland spar was added to distilled water which had been saturated with  $\text{CO}_2$ , shaken and filtered.

TABLE XXXVI.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to XXX DISTILLED WATER of MEASURED QUANTITIES of a HARD LIMESTONE WATER (Settle Public Supply).

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ " ) completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	August 20th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, added to 1 c.c. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character. No action in (b), but a bluish-white firmly-adherent film was formed on the metal.	Not recorded.
2	September 30th, 1894:— (a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, with 0.1 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. of same water, with 1.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water, with 5.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. of same water, with 10.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character. Decided action also in (b), (c), (d). In (e) no action. Lead renewed in (e) at intervals—October 1st, 1894, once; October 2nd, twice; October 4th, 1894, thrice; October 5th, thrice; October 6th, 1894, twice; October 7th, 1894, still no action.	

TABLE XXXVI.—*continued.*

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
3	November 30th, 1894:—		
	(a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character.	(a.) 20.0
	(b.) 10 c.c. of same water, with 2.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".	Decided action also in (b), (c), (d), (e). In (f) no action.	(b.) 10.0
	(c.) 10 c.c. of same water, with 4.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".	December 1st, 1894. Lead removed and acid added.	(c.) 12.5
	(d.) 10 c.c. of same water, with 6.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".	In the case of (f) a bluish-white firmly-adherent film was formed on the metal.	(d.) 12.5
	(e.) 10 c.c. of same water, with 8.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".		(e.) 10.0
	(f.) 10 c.c. of same water, with 10.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".		(f.) 0.0
4	January 21st, 1895:—		
	(a.) 10 c.c. XXX in test tube with lead $1 \times \frac{1}{4}$ ".	In (a) action commenced at once and was progressive in character.	(a.) 7.0
	(b.) 10 c.c. of same water, with 2.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".	Decided action also in (b) and (c). In (d), (e), (f), (g) no action.	(b.) 4.0
	(c.) 10 c.c. of same water, with 4.0 per cent. Settle water in test tube with lead $1 \times \frac{1}{4}$ ".	In the case of (d), (e), (f), (g) a bluish-white firmly-adherent film was formed on the metal.	(c.) 3.0
	(d.) 10 c.c. of same water, with 6.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".		(d.) 0.5
	(e.) 10 c.c. of same water, with 8.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".	After one hour lead removed, acid added, and the amount of lead estimated.	(e.) trace.
	(f.) 10 c.c. of same water, with 10.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".		(f.) trace.
	(g.) 10 c.c. of same water, with 20.0 per cent. Settle water, in test tube with lead $1 \times \frac{1}{4}$ ".		(g.) trace.

In both series of experiments it will be seen that the results were satisfactory, when about 5 to 10 per cent. of the artificially prepared and of natural waters were employed, the lead became coated with a firmly adherent bluish-white film which altogether prevented any erosion from taking place. It is to be noted that in Experiment 2, Table XXXVI., 10 per cent. of Settle water not only prevented erosion from taking place, but also placed the mixture in a state remote from the possession of erosive ability. That is, repeated renewal of the lead, as each piece became coated over, failed to use up the "plumbo-protective" substances present in the water, and thereby to initiate erosive action.

In the following table (Table XXXVII.) are grouped together a number of more or less isolated observations relating to erosion.

TABLE XXXVII.

Showing the ACTION, as regards EROSION of LEAD, of XXX DISTILLED WATER upon BRIGHT SHEET LEAD—(a) under Ordinary Conditions, (b) under the Various Conditions specified in the table hereunder.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

Experiment	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
1	September 24th, 1894:— (a.) 10 c.c. XXX distilled water (after filtering through filter paper) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water (after shaking with 0.1 per cent. chalk powder, and filtering through filter paper) in test tube with lead $1 \times \frac{1}{4}$ ". (c.) Same as (b), but 0.1 per cent. powdered limestone.	Action began at once in (a), no action in (b), (c). Lead renewed in (b), (c), September 26th and 28th. October 1st. Still no action in (b), (c), very great action in (a).	No record.
2	October 17th, 1894:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 0.1 per cent. ammonium carbonate in test tube with lead $1 \times \frac{1}{4}$ ".	Action began at once in (a), no action in (b). October 21st. Still no action in (b), very great action in (a).	
3	November 2nd, 1894:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water was first filtered through 50 c.c. limestone (pea size) in burette ( $\frac{1}{4}$ " diam.) at rate of 30 secs. per 10 c.c. (c.) Same as (b), but the water was twice filtered through the limestone. (d.) Same as (b), but the water was thrice filtered through the limestone. (e.) Same as (b), but the water was four times filtered through the limestone. (f.) Same as (b), but the water was five times filtered through the limestone.	Action began at once in all the tubes, but the "lead compound" produced was of a more curdy nature in (b) than (a), in (c) than (b), in (d) than (c), in (e) than (d) and in (f) than (e). November 3rd. (a), (b), (c), (d), (e), (f), tested.	(a.) 25.0 (b.) 25.0 (c.) 25.0 (d.) 25.0 (e.) 25.0 (f.) 10.0
4	November 12th, 1894:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + 0.1 per cent. ammonium carbonate. (c.) 10 c.c. XXX distilled water + 0.1 per cent. calcium phosphate and filtered. (d.) 10 c.c. XXX distilled water in test tube with "coated" lead $1 \times \frac{1}{4}$ ".—The coating was obtained by leaving bright sheet lead in contact with a hard limestone water (Settle water) for 24 hours and then allowing the lead to become dry.	Action began at once in (a), no action visible in (b), (c), (d). November 14th. Still no action in (b), (c), (d), very great action in (a). (a), (b), (c), (d), tested.	(a.) 30.0 (b.) Trace. (c.) Trace. (d.) Trace.
5	January 12th, 1895:— (a.) 10 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water frozen solid and then thawed.	Action began at once in both (a) and (b). January 15th. (a), (b), tested.	(a.) 20.0 (b.) 20.0
6	January 17th, 1895:— (a.) 10 c.c. XXX distilled water (after filtration) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first shaken with 0.1 per cent. powdered limestone and filtered. (c.) Same as (b), but 0.1 per cent. powdered polarite used instead of limestone. (d.) Same as (a). (e.) Same as (b). (f.) Same as (c).	January 18th. Action in (a), (c), (d), (f); no action in (b), (e), so lead renewed in (c). (a), (b), (c) tested. Lead renewed in (e) January 19th and 21st. January 22nd. Very great action in (d), (f), and only very slight action in (e). (d), (e), (f) tested.	(a.) 15.0 (b.) 0.5 (c.) 15.0 (d.) 30.0 (e.) 3.0 (f.) 50.0

TABLE XXXVII.—continued.

Experiment.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
7	January 23th, 1895:— (a.) XXX distilled water + 0.1 per cent. powdered flint shaken and then filtered. 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but 0.1 per cent. powdered Iceland spar used instead of flint.	Erosion distinct in (a), (b). February 2nd. (a), (b) tested.	(a.) 25.0 (b.) 25.0
8	February 2nd, 1895:— (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first shaken with 0.1 per cent. crushed flint and then the water was filtered. (c.) Same as (a), but the water first shaken with 0.1 per cent. crushed Iceland spar and then the water filtered.	February 3rd. Distinct action in (a), (b), no action in (c). (a), (b), (c) tested.	(a.) 10.0 (b.) 10.0 (c.) 0.0
9	February 8th, 1895:— (a.) XXX distilled water + 0 shaken and filtered. 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ ". (b.) XXX distilled water + 0.1 per cent. sodium phosphate shaken and filtered. 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ ". (c.) XXX distilled water + 0.1 per cent. calcium phosphate shaken and filtered. 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (a). (e.) Same as (b), but the water, after the phosphate treatment, diluted 90 per cent. with XXX distilled water. (f.) Same as (c), but the water, after the phosphate treatment, diluted 90 per cent. with XXX distilled water.	February 10th. Action began at once in (a), (d). No action in (b), (c), no action in (e), but action in (f). February 11th. Distinct action in (a), (d), (f). No action visible in (b), (c), (e). (a), (b), (c), (d), (e), (f) tested.	(a.) 10.0 (b.) 0.0 (c.) 0.0 (d.) 10.0 (e.) 0.0 (f.) 5.0
10 A	February 15th, 1895. (a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 cc. XXX distilled water + 0.1 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 cc. XXX distilled water + 0.2 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + 0.4 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + 0.6 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 cc. XXX distilled water + 0.8 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 cc. XXX distilled water + 1.0 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	February 17th, 1895. Action distinct in (a), (b), (c), (d). No action visible in (e), (f), (g). Amount of lead estimated.	(a.) 15.0 (b.) 15.0 (c.) 15.0 (d.) 10.0 (e.) 0.0 (f.) Trace. (g.) 0.0
B	(a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ of alkalinity equal to 0.1 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ of alkalinity equal to 0.2 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ of alkalinity equal to 0.4 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ of alkalinity equal to 0.6 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ of alkalinity equal to 0.8 per cent. $\text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	Action began at once in (a), (b), (c), (d). No action visible in (e), (f), (g). February 17th. Now some slight action in (e). Still no action in (f), (g). Amount of lead estimated.	(a.) 15.0 (b.) 15.0 (c.) 15.0 (d.) 15.0 (e.) 3.0 (f.) 0.0

TABLE XXXVII.—continued.

Experiment.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
10 B	February 15th, 1895— <i>cont.</i> (g.) 10 c.c. XXX distilled water + $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ of alkalinity equal to 1.0 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". The $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ was prepared by saturating distilled water with $\text{CO}_2$ , shaking with excess powdered Iceland spar and filtering.		(g.) 0.0
C	(a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + $\text{CaO}$ , $\text{H}_2\text{O}$ of alkalinity equal to 0.5 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + $\text{CaO}$ , $\text{H}_2\text{O}$ of alkalinity equal to 0.6 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + $\text{CaO}$ , $\text{H}_2\text{O}$ of alkalinity equal to 0.9 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + $\text{CaO}$ , $\text{H}_2\text{O}$ of alkalinity equal to 1.0 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + $\text{CaO}$ , $\text{H}_2\text{O}$ of alkalinity equal to 2.0 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. XXX distilled water + $\text{CaO}$ , $\text{H}_2\text{O}$ of alkalinity equal to 3.0 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	February 17th, 1895. Action in all the tubes, but not so distinct in (e), (f), (g) as in (a), (b), (c), (d). Amount of lead estimated.	(a.) 15.0 (b.) 20.0 (c.) 20.0 (d.) 25.0 (e.) 15.0 (f.) 5.0 (g.) 5.0
D	(a.) 10 c.c. XXX distilled water + 0 in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. XXX distilled water + $\text{NaHCO}_3$ of alkalinity equal to 0.1 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. XXX distilled water + $\text{NaHCO}_3$ of alkalinity equal to 0.2 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. XXX distilled water + $\text{NaHCO}_3$ of alkalinity equal to 0.4 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (e.) 10 c.c. XXX distilled water + $\text{NaHCO}_3$ of alkalinity equal to 0.6 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. XXX distilled water + $\text{NaHCO}_3$ of alkalinity equal to 0.8 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ". (g.) 10 c.c. XXX distilled water + $\text{NaHCO}_3$ of alkalinity equal to 1.0 per cent. $\frac{n}{10} \text{Na}_2\text{CO}_3$ in test tube with lead $1 \times \frac{1}{4}$ ".	February 17th. Action distinct in (a), (b), (c), (d). No action visible in (d), (e), (f). Amount of lead estimated.	(a.) 15.0 (b.) 15.0 (c.) 15.0 (d.) 15.0 (e.) 0.0 (f.) 0.0 (g.) 0.0

In Experiment 1, shaking XXX distilled water with powdered chalk and limestone and then filtering through filter paper, seemed in each case to place the water in a safe condition as regards erosive ability. This result in the case of limestone is confirmed in Experiment 6 (b) and (e). But repeated filtration through a small laboratory filter composed of pea-sized fragments of limestone did not suffice to deprive XXX distilled water of its erosive power (Experiment 3). In

Experiments 2 and 4, 0.1 per cent. of ammonium carbonate was found to inhibit the erosive ability of XXX distilled water. Calcium phosphate (Experiment 4 (c) and Experiment 9 (c), (f)) was also found to be an inhibitory agent. So also was sodium phosphate (Experiment 9 (b), (e)). In Experiment 4 (d) is also recorded the fact that XXX distilled water cannot readily erode lead which has previously acquired from contact with a hard limestone water a "plumbo-protective" coat. In Experiment 5 it is shown that a preliminary freezing of XXX distilled water does not modify the subsequent erosive action of this distilled water. The uselessness of polarite, as a remedial agent for erosion, seems to be indicated by the result of Experiment 6 (c) and (f). A similar result was obtained with flint (Experiment 7 (a) and Experiment 8 (b)). Iceland spar gave anomalous results, as, in one experiment, erosion was not inhibited (Experiment 7 (b)); whereas in another (Experiment 8 (c)) no erosion took place. In Experiment 10 A, B, C, D, the relative values as regards preventatives of erosion of sodium carbonate, calcium bicarbonate, limewater, and sodium bicarbonate are considered. Limewater (Experiment 10 c) was, as before, found to be of inferior value, but sodium carbonate, calcium bicarbonate, and sodium bicarbonate were all about equally efficacious, on the basis of an equal degree of alkalinity. It may be doubted whether in practice any substance can compare with sodium carbonate as a corrective for erosive ability.

#### *Summary (under Section I.(b)).*

To attempt any summary of the foregoing results is a difficult task. The experiments cover a wide field of research, and embrace many side issues. Undertaken often at spare moments during the stress of the routine chemical and bacteriological work, they may seem in consequence to lack continuity of purpose. Moreover, many of them were of a tentative sort, that is, experiments carried out without a clear knowledge of how they would eventually influence the research as a whole, but persevered with in the hope that some at least of them might throw fresh light on the general question of lead poisoning by moorland waters.

Taking the distillates of Settle water as a type of distilled water, it is to be noted that distilled water may be acid, plumbo-solvent, and non-erosive (X), or neutral, non-plumbo-solvent, and erosive (XXX). Further, that the former kind of water can be brought to the same condition as the latter in numerous ways, *e.g.*, by aeration, boiling and aerating, exhaustion of the dissolved gases and subsequent aeration, storing for some time in partially filled and unstoppered bottles, &c.

As regards XXX distilled water, this always erodes bright lead in vigorous fashion, but does not attack coated lead. Under anaerobic conditions there is no erosive action; but on allowing the water to become aerated again the power of erosion is restored. Similarly, either boiling the water or saturating it with hydrogen gas, if followed by aeration, does not inhibit erosion. Repeated distillation does not deprive XXX water of its erosive power. Alloys of lead and tin within certain limits inhibit erosion. Free exposure to the air favours progressive erosion, but an excess of pure oxygen gas dissolved in the water is seemingly a deterrent factor. Within certain limits, the longer the duration of contact the greater is the amount of lead compound formed. Light does not appear to influence materially the question of erosion. Certain salts, *e.g.*, ammonium chloride, magnesium sulphate, sodium chloride, calcium phosphate, sodium phosphate, and calcium sulphate (to a slight extent), inhibit erosion. The nitrates or nitrites



do not seem to have any very marked or uniform effect, with the exception of ammonium nitrate, which increases the action. Acids (in the amounts used) seem to delay rather than prevent erosion from taking place. Some alkaline substances, particularly bicarbonate of calcium and the carbonate and bicarbonate of sodium, have a strong inhibitory action. So has a hard water, if the hardness be due to the presence of bicarbonate of calcium. Storing XXX water for long periods in partially filled and unstoppered or in completely filled and stoppered bottles does not seemingly alter the erosive power of the water. Filtering XXX water repeatedly through limestone chips does not seem to prevent erosion; but shaking with powdered chalk or powdered limestone and then filtering through filter paper tends to inhibit erosive action. Silica, either in the form of powder ( $\text{SiO}_2$ ) or as powdered flint, when shaken with XXX water, has no power of imparting to the water any "plumbo-protective" ability. Polarite is also useless in this sense.

From the above notes a table may be constructed; it should be remembered, however, that such a table is to be interpreted only in the light of the detailed statements which have been already given.

Substances or Conditions which do not influence, to any material extent, Erosion.	Substances or Conditions which tend to increase Erosion.	Substances or Conditions which inhibit, to a great or less extent, Erosion.	Substances or Conditions which delay, rather than inhibit, Erosion.
Silica, powdered flint, powdered polarite, shaken with the water, and then filtered. Repeated filtration through limestone (in the laboratory). Storing for long periods in partially filled and unstoppered bottles or in bottles completely filled and stoppered. Boiling, if followed by aeration. Aspirating air through the water. Saturation with hydrogen gas if followed by aeration. Repeated distillation. Presence or absence of light. [? Addition to the water of sodium and potassium nitrate and nitrite.] Exhaustion of the dissolved gases if followed by aeration.	Ammonium nitrate. Complete aeration. Prolonged contact. Free exposure of the surface of the liquid to the air.	Anaerobic conditions. Saturation with pure hydrogen gas. Saturation with pure oxygen gas. Ammonium carbonate. Sodium carbonate. Sodium bicarbonate. Calcium bicarbonate. Calcium phosphate. Sodium phosphate. Magnesium sulphate. Calcium sulphate. Ammonium chloride. Sodium chloride. "Coated" lead. Hard limestone water. Lime water (slight). Alloys of lead and tin. Shaking with powdered chalk and limestone and then filtering.	[? Mineral acids (in the strengths used) and carbonic acid water.] Imperfect aeration.

#### (c).—Moorland Waters.

The study of the erosive power exhibited by certain moorland waters is attended with numerous difficulties.\* The subject is complicated by the parallel question of plumbo-solvency, which cannot be readily dissociated from erosive ability. Moreover, the property of erosion in the case of moorland waters is seldom as marked as in the case of distilled waters; points of difference are hence apt to be "masked" and even overlooked. Again, erosion occurs in a different fashion in moorland waters as compared with distilled water. With distilled waters erosion, if it takes place at all, speedily shows itself as a clearly visible cloudiness in a perfectly transparent liquid. With moorland waters there may be at first no apparent action; the liquid is often of a yellowish tint with suspended matter, making observations difficult; the

\* Plate XII., Fig. 15, a, b, c, d.

lead may become coated at the outset with a seemingly satisfactory film, and only much later this coating may begin to fall away in flakes from the surface of the metal, leaving patches open to erosive action.

Perhaps the subject will be best approached by the preliminary consideration of Table XXXVIII., which deals with the action as regards erosion of lead of certain moorland waters upon bright sheet lead.

TABLE XXXVIII.

Showing the ACTION, as regards EROSION of LEAD, of certain MOORLAND WATERS upon BRIGHT SHEET LEAD.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
1	August 25th, 1894:— (a.) 10 c.c. Mytholmroyd Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. Withins Stream water in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. Jack Clough Stream water in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. Fletcher's Dyke Stream water in test tube with lead $1 \times \frac{1}{4}$ ".	0'30 0'42 0'42 1'70	September 24th. Slight erosion in (a), great in (d), none visible in (b), (c).	
2	September 13th, 1894:— (a.) 10 c.c. Wakefield "treated" water in test tube with lead $1 \times \frac{1}{4}$ ". (Plate XVI.) (a <sup>1</sup> .) Same as (a). (b.) 10 c.c. Wakefield "untreated" water in test tube with lead $1 \times \frac{1}{4}$ ". (b <sup>1</sup> .) Same as (b).	Neutral 0'84	Lead renewed in (a <sup>1</sup> ) September 14th, 16th, 17th, 18th, 19th, 21st and 24th. October 10th. No action in (a) and no action in (a <sup>1</sup> ), notwithstanding frequent renewal of lead. As regards (b) and (b <sup>1</sup> ), by September 17th, distinct action in both the tubes.	
3	September 14th, 1894:— (a.) 10 c.c. Brushes Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (Plate XV.) (b.) Same as (a). (c.) 10 c.c. Lower Swineshaw Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (b). (e.) 10 c.c. Higher Swineshaw Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (f.) Same as (e). (g.) 10 c.c. Yeoman Hay Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (h.) Same as (g).	Neutral 0'42 0'60 0'42	September 16th and 17th. Lead renewed in (b), (d), (f), (h). September 18th. No action in (a), (c), (e), but slight action in (g). Action in all the tubes where the lead was renewed, viz., (b), (d), (f), (h). October 10th. Still no action in (a), (c), (e), action in (g) but not so marked as in the case of (h). Distinct action in (b), (d), (f), (h).	
4	September 28th, 1894:— (a.) 10 c.c. Keighley Watersbeddels Reservoir water (before filtration) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a) but after filtration. (c.) 10 c.c. No. 13 acid peat feeder to Watersbeddels Reservoir in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (a). (e.) Same as (b). (f.) Same as (c).	0'46 Neutral 0'60	September 29th. Lead renewed in (d), (e), (f). October 11th. No action visible in (a), (b), and only very slight in (c). Action in (d), (e), (f), greatest in (d) and least in (f).	

TABLE XXXVIII.—*continued.*

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
5	October 18th, 1894:— (a.) 10 c.c. Leeds main water in test tube with lead $1 \times \frac{1}{4}$ " (b.) Same as (a). (c.) 5 c.c. of same water as in (a) + 5 c.c. XXX distilled water.	Neutral	October 19th and 20th. Lead renewed in (b). October 27th. No action visible in (a), (b), (c).	
6	October 18th, 1894:— (a.) 10 c.c. of same water as in Experiment 2 (b) in test tube with lead $1 \times \frac{1}{4}$ ".	0.84	By October 20th, action distinct. October 22nd, action very great. Amount of lead estimated.	(a.) 40.0
7	October 22nd, 1894:— (a.) 10 c.c. Wicken spring water (No. 1) in test tube with lead $1 \times \frac{1}{4}$ " (b.) Same as (a). (c.) 10 c.c. Wicken spring water (No. 2) in test tube with lead $1 \times \frac{1}{4}$ " (d.) Same as (c). (e.) 10 c.c. Wicken spring water (No. 3) in test tube with lead $1 \times \frac{1}{4}$ " (f.) Same as (e). (g.) 10 c.c. Wicken spring water (No. 4) in test tube with lead $1 \times \frac{1}{4}$ " (h.) Same as (g). (i.) 10 c.c. Wicken spring water (No. 5) in test tube with lead $1 \times \frac{1}{4}$ " (j.) Same as (i). (k.) 10 c.c. Wicken Brook in test tube with lead $1 \times \frac{1}{4}$ " (l.) Same as (k).	Neutral	October 23rd and 24th. Lead renewed in (b), (d), (f), (h), (j), (l). October 26th. Action in (h), (j), not in any of the other tubes. Lead renewed in (b), (d), (f), (l). October 27th. Still no action in (a), (b), (c), (d), (e), (f), (g), (i), (k), (l), but distinct action in (h), (j). Lead again renewed in (b), (d), (f), (l). October 28th. (b), (d), (f), (l) now showed action. Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) Traces. (b.) 5.0 (c.) Traces. (d.) 5.0 (e.) Traces. (f.) 10.0 (g.) Traces. (h.) 20.0 (i.) Traces. (j.) 20.0 (k.) Traces. (l.) 5.0
8	October 26th, 1894:— (c.) 10 c.c. water from neutral ferruginous stream (D 1) entering Graincliffe stream (Shipley Waterworks) in test tube with lead $1 \times \frac{1}{4}$ " (d.) Acid peat feeder (D 12) to Graincliffe stream, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ " (e.) Acid peat feeder (D 8) to Black Dyke stream, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ " (f.) Acid peat feeder (D 2) to Graincliffe stream, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ " (g.) Acid peat feeder (D 9) to Graincliffe stream, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ " (h.) Acid peat feeder (D-5) to Graincliffe stream, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ " (m.) Weecher stream, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ " (n.) Eldwick Reservoir water, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ " (o.) Black Dyke stream, 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral Acid " " " " " 1.06 0.96 1.20	November 5th, 1894. No action visible in (c), action in (d), (e), (f), (g), (h), (m), (n), (o). Action greatest in (o). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(c.) 1.0 (d.) 6.0 (e.) 4.0 (f.) 14.0 (g.) 4.0 (h.) 12.0 (m.) 5.0 (n.) 10.0 (o.) 25.0
9	November 3rd, 1894:— (a.) 10 c.c. Morley main water in test tube with lead $1 \times \frac{1}{4}$ " (b.) Same as (a).	? Trace acid.	November 4th. No action visible in (a), (b), so lead renewed in (b). November 14th. Still no action in (a), distinct action in (b).	No record.

TABLE XXXVIII.—continued.

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
10	November 16th, 1894:— (a.) 10 c.c. Wakefield water after "treatment" in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.).	Neutral	December 11th. No action in (a), (b). Lead removed, acid added to contents of tubes, and amount of lead tested for.	(a.) 0'0 (b.) 0'0
11	November 17th, 1894. 10 c.c. of each of the following feeders to Watersheddels Reservoir (Knighley Waterworks) in test tubes with lead $1 \times \frac{1}{4}$ " :— (a.) No. 13, acid . . . . (b.) A. neutral . . . . (c.) No. 11, ferruginous stream, neutral. . . . . (d.) No. 10, acid . . . . (e.) Z conduit water, acid . . (f.) No. 16, neutral . . . . (g.) No. 3, neutral . . . . (h.) No. 3, neutral . . . . (i.) No. 4, acid . . . . (j.) No. 5, acid . . . .	0'72 Neutral " 0'60 0'72 Neutral " 0'48 0'72	January 7th, 1895. Little or no action in (b), (c), (f), (g), (h), (i). Distinct action in (a), (d), (e), (j). Amount of lead estimated.	(a.) 10'0 (b.) 1'0 (c.) 0'5 (d.) 10'0 (e.) 15'0 (f.) 1'0 (g.) 2'5 (h.) 0'5 (i.) 0'5 (j.) 20'0
12	November 17th, 1894:— (a.) 10 c.c. Watersheddels Re- servoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same water as in (a), but after leaving filtration works. (d.) Same as (c).	0'54 Neutral	November 19th. Lead re- newed in (b), (d). November 21st. Action now in (b), (d), none visible in (a), (c). November 24th. Enormous action in (b), (d), no action apparently in (c) and only very slight in (a). (a) and (c) tested. January 7th, 1895. (b) and (d) tested.	(a.) 2'0 (b.) 160'0 (c.) Trace (d.) 20'0
13	November 24th, 1894:— (a.) 10 c.c. River Don (before entrance to Dunford Reser- voir) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Neutral	November 26th. No action (a), (b), so lead renewed in (b). December 8th. Still no action (a), (b), so lead again re- newed in (b). January 7th, 1895. Still no action in (a) but distinct action in (b). Amount of lead estimated.	(a.) 0'5 (b.) 25'0
14	November 24th, 1894. 10 c.c. of each of the following supply streams to Dunford Reservoir in test tubes with lead $1 \times \frac{1}{4}$ " :— (a.) Great Grain Clough, acid (b.) Same as (a). (c.) Little Grain Clough, acid (d.) Same as (c). (e.) Dearden Clough, neutral (f.) Same as (e). (g.) Swine Clough, acid (h.) Same as (g).	Acid Neutral Acid	November 25th. No action visible in any of the tubes, so lead renewed in (b), (d), (f), (h). December 8th. Still no action (a), (c), (e), and only trace in (g). No action in (b), (d), (f), but great action in (h). Lead renewed in (b), (d), (f). January 7th, 1895. No action visible in (a), (c), (e), and only very slight in (g). No action apparently in (d), distinct action in (b), (f), (h). Amount of lead esti- mated.	(a.) 1'0 (b.) 30'0 (c.) 2'0 (d.) 1'5 (e.) 1'0 (f.) 25'0 (g.) 35'0 (h.) 45'0

TABLE XXXVIII.—continued.

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. of $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
15	January 23rd, 1895:— (a.) 10 c.c. Dunford Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. of the same water as in (a) + 5 c.c. XXX distilled water.	0.42	January 26th, 1895. No action visible in (a), very decided action in (b). Amount of lead estimated.	(a.) 1.0 (b.) 20.0
16	January 31st, 1895:— (a.) 10 c.c. Brushes Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. of the same water as in (a) + 5 c.c. XXX distilled water.	Neutral	February 14th, 1895. No apparent action in (a), (b). Amount of lead estimated.	(a.) 0.5 (b.) 1.0
17	February 6th 1895:— (a.) 10 c.c. Morley main water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	0.60	February 7th. Lead renewed in (b). February 9th. Action in (b), no action visible in (a). Amount of lead estimated.	(a.) 2.0 (b.) 10.0
18	February 8th, 1895:— (a.) 10 c.c. Keighley water (after filtration) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Neutral	February 9th. Lead renewed in (b). February 13th. No action visible in (a); distinct action in (b). Amount of lead estimated.	(a.) 0.5 (b.) 15.0
19	May 1st 1895:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Trace acid	Experiments 19 to 24 are a continuation of Table XXXIX. (Table XXXIX. deals with Mossley water before it was treated with lime). Lead renewed in (b) May 2nd and 3rd. May 8th. No action visible in (a); distinct in (b). Amount of lead estimated.	(a.) 0.5 (b.) 10.0
20	May 9th, 1895:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	"	Lead renewed in (b) May 11th. May 15th. Distinct action in (a), none in (b). Amount of lead estimated.	(a.) 0.5 (b.) 12.5
21	May 14th, 1895:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	"	Lead renewed in (b) May 16th. May 20th. Distinct action now in (b) and none in (a).	(a.) Trace. (b.) 7.5
22	May 31st, 1895:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	"	Lead renewed in (b) May 23rd and 24th. May 28th. No action in (a), very marked action in (b).	(a.) 0.5 (b.) 20.0
23	May 29th, 1895:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	"	May 31st. Lead renewed in (b). June 6th. No action in (a), distinct in (b).	(a.) Trace. (b.) 15.0
24	June 6th, 1895:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	"	Lead renewed in (b) June 7th, 8th, 9th. June 13th. Now marked action in (b) and no action in (a).	(a.) 0.5 (b.) 15.0
25	May 17th, 1895:— (a.) 10 c.c. filtered Keighley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. Keighley water before filtration in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (a).	Neutral  0.54	Lead renewed in (b), (d) as no action. May 23rd. No action in (a), action distinct in (b), (c), (d). Amount of lead estimated.	(a.) 0.5 (b.) 15.0 (c.) 7.5 (d.) 10.0

TABLE XXXVIII.—*continued.*

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{N}_2\text{S}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
26	May 28th, 1895:— (a.) 10 c.c. filtered Keighley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.). (c.) 10 c.c. Keighley water before filtration in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c.).	Neutral  0·48	Lead renewed in (b), (d), May 29th. June 5th. No action visible in (a); distinct in (c); very marked action in (b), (d).	(a.) 0·5 (b.) 20·0 (c.) 10·0 (d.) 20·0
27	June 1st, 1895:— (a.) 10 c.c. Sheffield main water (High level) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.). (c.) 10 c.c. Sheffield main water (Low level) in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c.).	Neutral  "	June 2nd. Lead renewed in (b), (d) as no action. June 3rd. Slight action now in (b), none in (d), so lead renewed in (d). June 8th. No apparent action (a), (c), distinct in (b), (d).	(a.) 0·5 (b.) 10·0 (c.) 0·5 (d.) 25·0
28	June 6th, 1895:— (a.) 10 c.c. Todmorden main water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.).	Slightly acid.	June 7th. Lead renewed in (b). June 12th. Slight action in (a); very marked action in (b).	(a.) 5·5 (b.) 35·0
29	June 8th, 1895:— (a.) 10 c.c. Keighley filtered water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.). (c.) 10 c.c. Keighley water before filtration in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c.).	Neutral  0·54	June 9th. Lead renewed in (b), (d). June 19th. No action visible in (a), and only slight in (b), (c); very great action in (d).	(a.) 0·5 (b.) 5·0 (c.) 7·5 (d.) 45·0
30	June 13th, 1895:— (a.) 10 c.c. Bradford main water (High level) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.). (c.) 10 c.c. Bradford main water (Low level) in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c.).	Neutral  "	Lead renewed in (b), (d), June 13th, 14th, 15th, 16th, and 17th. June 28th. No apparent action in (a), (b), (c), (d).	(a.) 0·5 (b.) 0·5 (c.) 0·0 (d.) 0·5
31	June 15th, 1895. 10 c.c. of each of the following waters (Sheffield Waterworks) in test tubes with lead $1 \times \frac{1}{4}$ " :— (a.) Bradfield water - - (b.) " " (c.) Strines Reservoir water - (d.) " " (e.) Ogden Reservoir water - (f.) " " (g.) Hadfield Reservoir water (h.) " " (i.) Lower Redmires Reservoir water. (j.) Lower Redmires Reservoir water. (k.) Higher Redmires Reservoir water. (l.) Higher Redmires Reservoir water.	Neutral  " " " " " 0·24 " 0·36 "	June 16th. Lead renewed in (b), (d), (f), (h), (j), (l). June 16th. Lead again renewed in (d). June 23rd. Distinct action (b), (d), (f), (h), (j), (l). No apparent action in (a), (c), (e). Action in (g), (i), (k). Amount of lead estimated.	(a.) 0·5 (b.) 15·0 (c.) 1·5 (d.) 25·0 (e.) 0·5 (f.) 25·0 (g.) 5·0 (h.) 10·0 (i.) 10·0 (j.) 35·0 (k.) 15·0 (l.) 30·0

TABLE XXXVIII.—continued.

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
22	June 19th, 1895. 10 c.c. of each of the following waters (Bradford High Level Waterworks) in test tubes with lead $1 \times \frac{1}{4}$ "— (a.) Thornton Moor Reservoir water, before treatment. (b.) Thornton Moor Reservoir water, before treatment. (c.) Thornton Moor Reservoir water, after treatment. (d.) Thornton Moor Reservoir water, after treatment. (e.) Moss Spring water (f.) " " " (g.) Stubden Reservoir water (h.) " " "	0.48  Neutral  " "	June 20th. Lead renewed in (b), (d), (f), (h). June 21st. 2nd, 23rd. Lead renewed in (d), (f), (h). June 24th. Lead renewed in (d), (h). June 28th. Distinct action (a), (b), (f); no action visible (c), (d), (e), (g), (h). Amount of lead estimated.	(a.) 20.0 (b.) 30.0 (c.) Trace. (d.) Trace. (e.) Trace. (f.) 25.0 (g.) 1.0 (h.) 0.5
23	June 26th, 1895. 10 c.c. of each of the following waters (Batley Waterworks) in test tubes with lead $1 \times \frac{1}{4}$ "— (a.) Yateholme Reservoir water. (b.) Yateholme Reservoir water. (c.) Ramsden Clough . (d.) " (e.) Yateholme spring water. (f.) " " "	? Trace acid  Neutral "	June 27th. Lead renewed in (b), (d), (f). June 28th. Lead renewed in (f). June 29th. Lead renewed in (f). June 30th. Lead renewed in (f). July 3rd. No apparent action in (a), (c), (e), (f), distinct action in (b), (d). Amount of lead estimated.	(a.) 1.0 (b.) 30.0 (c.) Trace. (d.) 20.0 (e.) 0.0 (f.) Trace.
24	July 10th, 1895.— (a.) 10 c.c. filtered Keighley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. filtered Keighley water in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. Keighley water before filtration, in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. Keighley water before filtration, in test tube with lead $1 \times \frac{1}{4}$ ".	? Trace acid  0.48	July 11th. Lead renewed in (b), (d). July 15th. No action in (a), distinct action in (b), (c), (d). Amount of lead estimated.	(a.) Trace. (b.) 15.0 (c.) 5.0 (d.) 10.0
25	July 18th, 1895.— (a.) 10 c.c. Barnsley Reservoir (Ingbirchworth) unfiltered water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. Barnsley Reservoir (Ingbirchworth) unfiltered water in test tube with lead $1 \times \frac{1}{4}$ ". (c.) 10 c.c. Barnsley water after filtration through filter beds containing sand and limestone, in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. Barnsley water after filtration through filter beds containing sand and limestone, in test tube with lead, $1 \times \frac{1}{4}$ ". (e.) 10 c.c. Barnsley water after filtration through filter beds containing sand and pebbles (no limestone), in test tube with lead $1 \times \frac{1}{4}$ ". (f.) 10 c.c. Barnsley water after filtration through filter beds containing sand and pebbles (but no limestone), in test tube with lead $1 \times \frac{1}{4}$ ".	Neutral  " " "	July 14th. Lead renewed in (b), (d), (f). July 22nd. Distinct action in (b), (f), slight action in (a), none visible in (c), very slight in (d), (e). Amount of lead estimated.	(a.) 8.0 (b.) 20.3 (c.) 0.5 (d.) 2.0 (e.) 2.0 (f.) 15.0

Experiment 1 indicates the strong erosive power of Fletcher's Dyke stream, a highly acid feeder supplying Mytholmroyd Reservoir. Experiment 2 is of considerable interest. It shows that Wakefield "treated" water, even when the lead was renewed repeatedly, was unable to erode lead; whereas the "untreated" water showed a distinct action on lead. Experiment 3 exemplifies the fact that many moorland waters, although not possessed of appreciable erosive power, are very near the possession of this ability (Plate XV., Fig. 18). Thus a single renewal of the lead may exhaust the "plumbo-protective" substances present in the water, and so initiate vigorous action. Experiment 4 teaches a similar lesson. On the other hand, Leeds water, which contains more spring water than those previously considered, is evidently, judging from Experiment 5, further removed from this ability to erode lead. Experiment 6 deals with the same water as in Experiment 2 (*b*) and is a good example of an acid moorland water possessed of vigorous erosive power. Experiment 7 is of interest because it deals with (excepting (*k*), (*l*), mixture of spring and peaty water) almost pure moorland spring water, and shows that such water has no erosive power, and indeed requires as a rule repeated renewal of the lead to induce erosion to take place. Experiment 8 relates to peaty waters obtained from the Shipley Waterworks moorland gathering ground. All the waters were acid and eroded lead to a greater or less extent, except one, in which the action was scarcely appreciable. This sample was an example of a neutral ferruginous water. Experiments 9 and 17 show that Morley main water was very near the possession of erosive ability. Experiment 10 shows how satisfactory is the treatment of Wakefield water with sodium carbonate. Experiment 11 deals with the examination of a number of "feeders" to Watersheddel's Reservoir, Keighley Waterworks. Generally speaking, the acid samples eroded lead and the neutral showed little or no erosive power. Experiment 12 shows the enormous increase in erosive power produced by a single renewal of the lead in the case of the Watersheddel Reservoir water before filtration. It also shows that, although the filtered† water had no erosive power, the filtration process had no power to put the water in a position remote from the possession of erosive ability, since a single renewal of the lead started a vigorous action.

Experiment 13 shows that the River Don the main feeder to Dunford Reservoir, Dewsbury Waterworks, has no appreciable erosive power, but that a twice repeated renewal of the lead sufficed to induce erosion.

Experiment 14 deals, as regards erosion, with other supply streams to Dunford Reservoir. Swine Clough acid water alone eroded lead to any marked extent; but Great Grain Clough and Dearden Clough waters were near the possession of this ability, as is shown by the effect of the renewal of the lead. Experiment 15 shows that Dunford Reservoir water has no appreciable erosive power; but that, if it be diluted one half with XXX distilled water, considerable erosion takes place. A similar experiment (Experiment 16) was carried out with Brushes Reservoir water (Ashton under-Lyne Waterworks); but here the addition of the XXX water did not induce any marked erosion, showing that Brushes Reservoir water contains a larger amount of plumbo-protective substance than is possessed by the water of Dunford Reservoir. Experiment 18 shows that Keighley water, after filtration, although giving rise in the first instance to no appreciable erosion, is not far

\* The water is treated with sodium carbonate. Plate XVI., Fig. 19.

† The water is filtered through coke, sand, limestone, and polarite.



removed from possession of this quality. Experiments 19 to 24 deal with Mossley water after the lime treatment had been put in operation. They show that such treatment does not place a moorland water in a position remote from the possession of erosive ability. Experiments 25, 26, 29, 34, deal with Keighley water before and after filtration. Before filtration the water was acid and eroded lead. After filtration the water was neutral and no longer eroded lead; but it is to be noted that the filtration did not entirely counteract the tendency to erode lead initially possessed by the water, since a single renewal of the lead sufficed to induce a decided erosive action. Experiments 27 and 28 deal respectively with Sheffield (high and low level supply) and Todmorden main waters. The Sheffield water was readily induced to erode lead by a single renewal of the piece of lead; the Todmorden water eroded lead to some extent in the first instance.

Experiment 30 shows that Bradford main water (high and low level supply) was seemingly well on the safe side as regards erosion, since a renewal of the lead on five separate occasions failed to induce erosion. Experiment 31 deals with some experiments with waters obtained from the high and low level gathering grounds of Sheffield Waterworks. Generally speaking, the acid waters eroded lead in the first instance, and the neutral waters required the lead to be at least once renewed in order to induce erosion to take place.

Experiment 32 deals with waters obtained from the high-level gathering ground of the Bradford Waterworks. Thornton Moor Reservoir water, before treatment, was acid and eroded lead in decided fashion. After treatment the water was neutral and bore renewal of the lead on three occasions without exhausting its "plumbo-protective" power. Stubden Reservoir water had no appreciable erosive power, and renewal of the lead did not induce erosion to take place. Moss spring water did not erode lead in the first instance, but a renewal of the lead on two occasions was followed by an erosive action.

In Experiment 33 the results of the examination of Batley waters are given. The waters displayed in the first instance little appreciable erosive power; but a single renewal of the lead induced erosion in the case of Yateholme Reservoir water and Ramsden Clough water. Yateholme spring water, on the contrary, bore renewal of the lead on four occasions, without its "plumbo-protective" power being entirely exhausted.

Experiment 35 deals with Barnsley water. The unfiltered reservoir water eroded lead in the first instance to some extent; a single renewal of the lead greatly increased the action. The filtered water was on the whole satisfactory; but the filter beds, containing no limestone, did not appear to place the water on the safe side, as regard erosive ability, since on a single renewal of the lead decided erosion ensued.

The experiments given in the above table have been considered in some detail, because they serve to illustrate some points of considerable importance. For example, they show that an acid moorland water not uncommonly erodes lead to an appreciable extent, and that a neutral moorland water does not usually erode lead, but is near the possession of erosive ability. Finally, that although "treatment" of an acid moorland water possessed of erosive ability usually renders it neutral and non-erosive, the water commonly remains in a position so near the possession of erosive ability as to be probably still, under certain circumstances, potentially dangerous. This, however, is not the case when sodium carbonate is used (*see results with Wakefield water*).

It is convenient to consider in the next place Table XXXIX.

TABLE XXXIX.

Showing the ACTION, as regards EROSION of LEAD, of MOSSLEY WATER upon BRIGHT SHEET LEAD: (a) under ordinary conditions; (b) upon renewal of Lead.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ "') completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	August 14th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) August 15th and 16th. By August 29th, very great action in (b). Some action also in (a), but very slight compared with (b).	No record.
2	August 22nd, 1894:— (a.) 10 c.c. Mossley water in test tube with bright lead $1 \times \frac{1}{4}$ ". (Plate VIII.) (b.) Same as (a).	Lead renewed in (b) on August 23rd and 24th. Erosion commenced in (b) August 25th. September 4th. Great action in (b); none visible in (a).	No record.
3	August 29th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) on August 30th, 31st, and September 1st. By September 4th, erosion distinct in (b); none in (a). September 17th, 1894. Very great action in (b), still none visible in (a).	No record.
4	September 11th, 1894:— (a.) 10 c.c. Mossley water in test tube, with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) on September 13th. By September 14th, erosion in (b), but none in (a). September 24th. Very great action in (b); none in (a).	No record.
5	September 18th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) on September 19th and 20th. By September 21st, erosion in (b), but none in (a). September 26th. Very great action in (b); none in (a).	No record.
6	October 2nd, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) on October 4th, 5th, and 6th. By October 7th, erosion in (b); none in (a). By October 15th, very great action in (b); none in (a).	No record.
7	October 9th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) on October 10th, 11th, and 12th. By October 13th, erosion in (b); none in (a). By October 21st, very great action in (b); none in (a).	No record.
8	October 16th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a).	Lead renewed in (b) on October 17th, 21st. By October 23rd, erosion in (b); none in (a).	No record.

TABLE XXXIX.—*continued.*

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
9	November 7th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.)	Lead renewed in (b) on November 8th and 9th. By November 10th, erosion in (b), none apparent in (a).  November 20th. Very great action in (b); none apparent in (a). Lead removed and acid added, and the amount of lead estimated.	(a) = 1.0 (b) = 50.0
10	November 28th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.)	Lead renewed in (b) on November 29th and 30th. By December 1st, erosion in (b); none apparent in (a).  January 12th, 1895. Very great action in (b); none apparent in (a). Lead removed, acid added, and amount of lead estimated.	a = 0.5 b = 80.0
11	December 5th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.)	Lead renewed in (b) on December 6th, 7th, and 8th. By December 9th, action in (b); none apparent in (a).  January 14th, 1895.—Very great action in (b); still none apparent in (a). Lead removed, acid added, and lead estimated.	a = 1.0 b = 80.0
12	December 12th, 1894:— (a.) 10 c.c. Mossley water in test tube with bright sheet lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.)	Lead renewed in (b) on December 13th and 14th. By December 15th, action in (b), none apparent in (a).  January 9th, 1895. Very great action in (b); none apparent in (a). Lead removed and acid added, and lead estimated.	a = 2.0 b = 80.0

These experiments were undertaken at a period prior to the adoption of the lime "treatment," which was subsequently put into operation. Mossley water was an example of a slightly acid and plumbo-solvent moorland water. It will be noted that the water displayed little or no appreciable erosive power in most instances; but that it was near the possession of this ability is abundantly shown, since a renewal of the lead one, two, or three times, sufficed to exhaust the "plumbo-protective" power of the water, and to induce vigorous erosion to take place. (Plate XII., Fig. 15, *e, f, g, h*, and Plate VIII., Fig. 11, *c, d*.)

In the following three tables (XL., XLI., and XLII.) the effect, as regards erosion of lead, of placing moorland waters under aerobic and anaerobic conditions, of storing for long periods in partially filled and unstoppered bottles, and of concentrating by boiling, are set forth in detail.

TABLE XL.

Showing the ACTION, as regards EROSION of LEAD, of certain ACID MOORLAND WATERS upon LEAD—(a) under AEROBIC and (b) under ANAEROBIC conditions. Compare with Table XII.

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	August 15th, 1894 :— (a.) 20 c.c. Shipley water in Roux tube, with strip of bright sheet lead. Aerobic. (b.) Same as (a), but the water first exhausted of air, and then sealed in the manner described in Experiment 1 (b), Table XII. Anaerobic.	The lead remained quite bright in (b), and there was no sign of erosion. In (a) the lead became coated, and erosion gradually took place. October 15th, (a) and (b) tested.	(a.) 2.0 (b.) 4.0
2	August 22nd, 1894 :— (a.) 20 c.c. Mossley water in Roux tube, with strip of bright sheet lead. Aerobic. (b.) Same as (a), but the water exhausted of air, and then sealed, as in Experiment 1 (b), Anaerobic.	By October 12th, 1894, no erosion apparent in (a), (b), but the lead was quite bright in (b) and coated in (a). (a), (b) tested October 12th, 1894.	Only traces of action in (a), (b).
3	August 22nd, 1894 :— (a.) 20 c.c. Shipley water in Roux tube with strip of bright sheet lead. Aerobic. (b.) Same as (a), but the water exhausted of air, and then sealed, as in Experiment 1 (b). Anaerobic.	October 12th, 1894. No erosion visible in (b), and the lead was quite bright. Traces of action apparently in (a), and the lead well coated. October 12th, 1894, (a), (b) tested.	(a.) 4.0 (b.) 3.0
4	April 2nd, 1894 :— (a.) 10 c.c. Shipley water in Roux tube, with strip of bright sheet lead. Aerobic. (b.) Same as (a), but the water exhausted of air, and then sealed, as in Experiment 1 (b). Anaerobic.	April 6th. Lead slightly dull in both (a) and (b), but especially in (a). No erosion visible. April 6th, (a), (b) tested.	(a.) 0.5 (b.) 0.5
5	April 4th, 1894 :— (a.) Same as (a), Experiment 4, but a different sample of Shipley water. Aerobic. (b.) Same as (b), Experiment 4, but a different sample of Shipley water. Anaerobic.	April 6th. Lead coated in (a), and some erosion. Lead almost of initial brightness in (b), and no erosion visible. April 6th, (a), (b) tested.	(a.) 2.0 (b.) 0.5
6	April 5th, 1894 :— (a.) 10 c.c. Mossley water in Roux tube, with strip of bright sheet lead. Aerobic. (b.) Same as (a), but the water exhausted of air, and then sealed, as in Experiment 1 (b). Anaerobic.	April 11th. No erosion visible in (a) or (b). Lead well coated in (a). In (b), lead almost of initial brightness. April 11th, (a), (b) tested.	Only traces in (a) and (b).

TABLE XLI.

Showing the EFFECT, as regards EROSION of LEAD, of keeping certain ACID MOORLAND WATERS for Varying Periods of Time in Partially Filled and Unstoppered Bottles. (Plate XVII.)

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

Experiment.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
A	January 10th, 1895. 10 c.c. of each of the following waters were placed in test tubes with lead $1 \times \frac{1}{2}$ " :— Shipley water of June 25th, 1894 (129 days).	February 1st, 1895. Distinct action in A, B, action in C, slight action in D, E, F, very slight action in G, H—especially the latter. Lead removed, acid added to contents of tubes, and amount of lead estimated.	A 15.0
B	" " " July 2nd, " (122 days).		B 15.0
C	" " " November 19th, 1894 (52 days).		C 10.0
D	Ringstone reservoir water of November 8th, 1894 (53 days).		D 6.0
E	Black Dyke stream of October 26th, 1894 (76 days).		E 8.0
F	Ardley water (before treatment), of November 15th, 1894 (56 days).		F 8.0
G	Graincliffe stream of October 26th, 1894 (76 days).		G 4.0
H	Weecher stream of October 26th, 1894 (76 days).		H 3.0

TABLE XLII.

Showing the EFFECT, as regards EROSION of LEAD, of the CONCENTRATION by boiling of SHIPLEY WATER. Compare with Table LXXXVI.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

No.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
1	(a.) February 5th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ ".	Acid	0.96	February 12th, 1895. Erosion of the lead in (a) and (b). Action apparently greater in (b) than (a). Lead removed, acid added, and amount of lead estimated.	(a.) 4.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	0.90		(b.) 7.5
2	(a.) February 12th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ ".	"	0.78	February 21st, 1895. No apparent erosion of the lead in (a), (b). Lead removed, acid added, and amount of lead estimated.	(a.) 1.0
	(b.) Same as (b), Experiment 1	"	1.26		(b.) 5.0

TABLE XLII.—*continued.*

No.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}^+\text{CO}_3^{\circ}$ required to neutralise 100. cc. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
3	(a.) February 17th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	Acid	0.54	February 27th, 1895. Erosion of lead hardly noticeable, but apparently a greater action in (b) than (a). Lead removed, acid added, and amount of lead estimated.	(a.) 1.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	0.72		(b.) 4.0
4	(a.) February 28th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	"	0.96	March 7th, 1895. Considerable amount of sediment; erosion of lead indistinct. Lead removed, acid added, and amount of lead estimated.	(a.) 6.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	1.74		(b.) 10.0
5	(a.) March 7th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	"	0.84	March 13th, 1895. Erosion of lead in (a) and (b), but apparently greater in (b) than (a). Lead removed, acid added, and amount of lead estimated.	(a.) 7.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	1.68		(b.) 18.0
6	(a.) March 13th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	"	0.90	March 19th, 1895. Considerable amount of sediment in (a) and (b), but particularly in the latter. Erosion indistinct. Lead removed, acid added, and amount of lead estimated.	(a.) 10.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	1.44		(b.) 7.5
7	(a.) March 20th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	"	0.90	March 26th, 1895. Erosion in (a) and (b). Lead removed, acid added, and amount of lead estimated.	(a.) 7.5
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	1.44		(b.) 7.5
8	(a.) March 26th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	"	0.84	April 2nd, 1895. Erosion in (a) and (b). Lead removed, acid added, and amount of lead estimated.	(a.) 5.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	1.44		(b.) 7.5
9	(a.) April 4th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	"	0.90	April 10th, 1895. Slight erosion in (a) and (b). Lead removed, acid added, and amount of lead estimated.	(a.) 7.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	1.68		(b.) 7.5
10	(a.) April 10th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ".	"	0.84	April 16th, 1895. Slight erosion in (a) and (b). Lead removed, acid added, and amount of lead estimated.	(a.) 7.0
	(b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	"	1.58		(b.) 7.5

TABLE XLII.—*continued.*

No.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
11	(a.) April 17th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	Acid "	0.72 1.20	April 22nd, 1895. Slight erosion in (a) and (b). Lead removed, acid added, and amount of lead estimated.	(a.) 7.5 (b.) 5.0
12	(a.) April 24th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	" "	0.78 1.44	May 1st, 1895. Erosion in (a) and (b), but greater in (a) than (b). Lead removed, acid added, and amount of lead estimated.	(a.) 10.0 (b.) 6.0
13	(a.) May 1st, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	" "	0.96 1.92	May 8th, 1895. Erosion in (a) and (b), but greater in (a) than (b). Lead removed, acid added, and amount of lead estimated.	(a.) 10.0 (b.) 7.0
14	(a.) May 9th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	" "	0.78 1.56	May 15th, 1895. Erosion in (a) and (b), but greater in (a) than (b). Lead removed, acid added, and amount of lead estimated.	(a.) 7.0 (b.) 5.0
15	(a.) May 16th, 1895. 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first concentrated by boiling to half its original bulk.	" "	0.78 1.56	May 21st, 1895. Erosion in (a) and (b). Lead removed, acid added, and amount of lead estimated.	(a.) 6.0 (b.) 7.0

As regards Table XL., the particular samples of moorland water used in the experiments were unfortunately not conspicuous by reason of erosive ability; and therefore the differences between the two sets of conditions were not shown as clearly as might otherwise have been the case. On the whole, however, the anaerobic conditions seemed to some extent to restrain erosion.

Table XLI. indicates that the prolonged storage of acid moorland waters does not deprive them of erosive power (Plate XVII., Fig. 20).

Table XLII. shows that concentration, by boiling to half its original bulk, of such an acid moorland water as Shipley water, does not remove its erosive power. Sometimes the action was increased, sometimes diminished, but never destroyed. Incidentally, it may be noted that the acidity was increased by boiling to an extent usually nearly corresponding to the degree of concentration.

The following table (Table XLIII.) shows the effect, as regards erosion of lead, of Shipley water upon lead which had previously been submitted to the action of a hard limestone water.

TABLE XLIII.

Showing the EFFECT, as regards EROSION of LEAD, of SHIPLEY WATER upon LEAD which had previously been SUBMITTED to the ACTION of a HARD LIMESTONE WATER.

[The coating was obtained by leaving bright sheet lead in contact with Settle water—a hard limestone water—overnight; and then washing with distilled water and allowing to dry.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	January 30th, 1895:— (a.) 10 c.c. Shipley water in test tube with bright lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, in test tube with coated lead $1 \times \frac{1}{4}$ ".	February 4th, 1895. Lead removed and acid added.	(a.) 7.5 (b.) 5.0
2	February 6th, 1895:— (a.) 10 c.c. Shipley water in test tube with bright lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, in test tube with coated lead $1 \times \frac{1}{4}$ ".	February 12th, 1895. Lead removed and acid added.	(a.) 4.0 (b.) 5.0
3	February 13th, 1895:— (a.) 10 c.c. Shipley water in test tube with bright lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water, in test tube with coated lead $1 \times \frac{1}{4}$ ".	February 20th, 1895. Lead removed and acid added.	(a.) 1.0 (b.) 3.0

The results seem to show that, although a neutral water cannot erode "coated" lead, the case is different with an acid water. Probably the acid acted on the coat in such a manner as to lessen its protective character, and so allowed erosion to take place.

The following tables (XLIV., XLV., XLVI., XLVII., XLVIII.) show the effect, as regards erosion of lead, of the addition of measured quantities of alkaline substances to moorland waters.

TABLE XLIV.

Showing the EFFECT, as regard EROSION of LEAD, of the addition to SHIPLEY WATER of MEASURED QUANTITIES of SODIUM CARBONATE ( $\text{Na}_2\text{CO}_3$ ).

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	September 10th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ .	Lead renewed in (b) on September 11th, 18th, 14th, 16th, 17th, 18th, 21st, and 24th. September 28th. Distinct action in (a); almost no action, however, in (b).	—
2	September 17th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ .	Lead renewed in (b) on September 19th, 20th, 21st, and 24th. September 28th. Distinct action in (a); no action in (b).	—



TABLE XLIV.—continued.

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000.)
3	October 2nd, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (c.) Same as (a), but water $\frac{1}{2}$ neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water $\frac{1}{3}$ neutralised with $\text{Na}_2\text{CO}_3$ . (e.) Same as (a), but water $\frac{1}{4}$ neutralised with $\text{Na}_2\text{CO}_3$ . (f.) Same as (a), but water $\frac{1}{5}$ neutralised with $\text{Na}_2\text{CO}_3$ .	By October 15th very distinct action in (a); none in (b); very slight in (c); slightly more in (d) than (c); and very distinct in (e) and (f).	—
4	October 8th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (c.) Same as (a), but water $\frac{1}{2}$ neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a). (e.) Same as (b). (f.) Same as (c).	October 9th. No action (a), (b), (c), (d), (e), (f). Lead renewed in (d), (e), (f). October 10th. Slight action (a), (d); no action (b), (c), (e), (f). Lead renewed in (e), (f). October 11th. Action (a), (d), (f); no action in (b), (c), (e). Lead renewed in (e). Lead renewed in (e) October 15th and 18th. October 21st. Action (a), (d), but greater in (d) than (a); no action (b), (c), (e), but action in (f).	—
5	October 30th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (c.) Same as (a), but water $\frac{1}{2}$ neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water $\frac{1}{3}$ neutralised with $\text{Na}_2\text{CO}_3$ .	November 5th. Distinct action (a) and (d), but especially the latter; no action visible in (c), (b). November 8th. Same appearances as observed on November 5th. Lead removed from tubes, acid added, and lead estimated.	(a) = 10·0 (b) = 0·5 (c) = 1·0 (d) = 45·0
6	November 27th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (c). (e.) Same as (a), but twice as much $\text{Na}_2\text{CO}_3$ added to water as was necessary to neutralise. (f.) Same as (e).	November 28th. Lead renewed in (b) (d) (f). November 30th. Slight action in (a); great action in (b); no action (c), (d), (e), (f). Lead renewed in (d), (f). Lead renewed in (d), (f), December 1st, 2nd, 4th, and 8th. January 5th, 1895. Action in (a), and very great action in (b). No action visible in (c) (d) (e) (f). Lead removed from tubes, acid added, and lead estimated.	(a) = 15·0 (b) = 90·0 (c) = Trace. (d) = 1·0 (e) = Trace. (f) = 1·0
7	December 4th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (c). (e.) Same as (a), but twice as much $\text{Na}_2\text{CO}_3$ added to water as was necessary to neutralise. (f.) Same as (e).	December 5th. Lead renewed in (b), (d), (f). December 6th. Action commenced in (b), but not in other tubes. Lead renewed in (d), (f). December 6th, 7th, 8th, 9th, 10th, 11th, 12th, and 13th. January 14th 1895. Slight action in (a); very great action in (b). No action visible in (c), (d), (e), (f). Lead removed from tubes, acid added, and lead estimated.	(a) = 8·0 (b) = 60·0 (c) = 0·5 (d) = 0·5 (e) = 0·5 (f) = 0·5

TABLE XLIV.—continued.

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
8	December 11th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (c).	December 12th. Lead renewed in (b) (d). December 18th. Lead renewed in (b) (d). December 14th. Action distinct in (b). Lead renewed in (d) December 14th and 15th. January 10th 1895. Slight action in (a); great action in (b). No action visible in (c) (d). Lead removed from tubes, acid added, and lead estimated.	(a.) = 5.0 (b.) = 12.0 (c.) = 0.5 (d.) = 0.5
9	January 15th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. Shipley + 5 c.c. XXX distilled water. (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (b), but water neutralised with $\text{Na}_2\text{CO}_3$ .	January 19th. Slight action in (a) (d). Distinct action in (b). No action in (c). Lead removed, acid added, and lead estimated.	(a.) = 5.0 (b.) = 10.0 (c.) = 0.5 (d.) = 6.0
10	January 22nd, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. Shipley water + 5 c.c. XXX distilled water. (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (b), but water neutralised with $\text{Na}_2\text{CO}_3$ . (e.) Same as (a), but twice as much $\text{Na}_2\text{CO}_3$ added to water as was necessary to neutralise. (f.) Same as (b), but twice as much $\text{Na}_2\text{CO}_3$ added to water as was necessary to neutralise. (g.) Same as (c), but water $\frac{1}{2}$ neutralised with $\text{Na}_2\text{CO}_3$ . (h.) Same as (d), but water $\frac{1}{2}$ neutralised with $\text{Na}_2\text{CO}_3$ .	January 26th. Distinct action in (a); very slight action in (g); and no action in (c), (e). Very great action in (b), (h); and no action in (f), (d). Lead removed, acid added, and lead estimated.	(a.) = 15.0 (b.) = 30.0 (c.) = 0.5 (d.) = 0.5 (e.) = 0.5 (f.) = 0.5 (g.) = 1.0 (h.) = 40.0
11	March 27th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water $\frac{1}{2}$ * neutralised with $\text{Na}_2\text{CO}_3$ .	April 2nd. Slight action in (a) and (b). Lead removed, acid added, and lead estimated.	(a.) = 5.0 (b.) = 4.0
12	April 4th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water $\frac{1}{2}$ * neutralised with $\text{Na}_2\text{CO}_3$ . (c.) Same as (b), but water $\frac{1}{2}$ * neutralised with $\text{Na}_2\text{CO}_3$ .	April 10th. Action in (a), (b), (c). Lead removed, acid added, and lead estimated.	(a.) = 7.5 (b.) = 7.5 (c.) = 7.5
13	April 10th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water* neutralised $\frac{1}{2}$ with $\text{Na}_2\text{CO}_3$ .	April 16th, 1895. Action in (a), (b), but greatest in (b). Lead removed, acid added, and lead estimated.	(a.) = 7.5 (b.) = 10.0

\* Methyl-orange here used as indicator: in all the other experiments phenol-phthalein unless otherwise stated, was used as indicator.

TABLE XLIV.—*continued*.

No.	Description of Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
14	<p>April 17th, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) Same as (a), but water <math>\frac{1}{2}</math>" neutralised with <math>\text{Na}_2\text{CO}_3</math>.</p> <p>(c.) Same as (a), but water <math>\frac{1}{2}</math>" neutralised with <math>\text{Na}_2\text{CO}_3</math>.</p>	<p>April 17th, 1895. Action in (a), (b), (c). Lead removed, acid added, and lead estimated.</p>	<p>(a.) = 7.5</p> <p>(b.) = 5.0</p> <p>(c.) = 5.0</p>
15	<p>April 24th, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) Same as (a), but water <math>\frac{1}{2}</math>" neutralised with <math>\text{Na}_2\text{CO}_3</math>.</p>	<p>May 1st, 1895. Marked action in (a), but in (b) action still more marked. Lead removed, acid added, and lead estimated.</p>	<p>(a.) = 10.0</p> <p>(b.) = 35.0</p>
16	<p>May 1st, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) Same as (a), but water <math>\frac{1}{2}</math>" neutralised with <math>\text{Na}_2\text{CO}_3</math>.</p>	<p>May 8th, 1895. Action in (a) and (b). Lead removed, acid added, and lead estimated.</p>	<p>(a.) = 10.0</p> <p>(b.) = 6.0</p>
17	<p>May 9th, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) Same as (a) but water <math>\frac{1}{2}</math>" neutralised with <math>\text{Na}_2\text{CO}_3</math>.</p> <p>(c.) Same as (a), but water <math>\frac{1}{2}</math>" neutralised with <math>\text{Na}_2\text{CO}_3</math>.</p>	<p>May 15th, 1895. Action (a), (b), (c). Lead removed, acid added, and lead estimated.</p>	<p>(a.) = 10.0</p> <p>(b.) = 5.0</p> <p>(c.) = 7.5</p>

\* Methyl-orange here used as indicator: in all the other experiments phenol-phthalein, unless otherwise stated, was used as indicator.

The table clearly shows the highly beneficial effect, as regards inhibition of erosion, of neutralising Shipley water with sodium carbonate. The results also indicate that partial neutralisation is not only unlikely to prevent erosion from taking place, but actually, in some cases, if the sodium carbonate be added in very small amount, increases the action.

On the other hand, the addition of excess of sodium carbonate, or even the quantity necessary exactly to neutralise, sufficed not only to prevent erosion from taking place, but also to place the water in a position remote from the possession of erosive ability; this is to be deduced from the failure to induce erosion after repeated renewal of the lead.

TABLE XLV.

Showing the EFFECT, as regards EROSION OF LEAD, of the ADDITION to certain WATERS (for the most part ACID MOORLAND WATERS) of MEASURED QUANTITIES of SODIUM CARBONATE ( $\text{Na}_2\text{CO}_3$ ). Compare with Table XLIV.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ " ) completely submerged.]

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	September 11th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ .	September 18th. No action (a), (b), (c). Lead renewed in (b), (c). September 14th. Action now distinct in (b). Lead renewed in (c) September 16th, 17th, 18th, 21st, and 24th, as no action. By September 24th still no action in (a), so lead renewed. September 28th. Distinct action in (a), (b), but little or no action in (c).	
2	September 14th, 1894:— (a.) 10 c.c. Wakefield water before "treatment" in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ .	September 16th. Distinct action in (a); none in (b). Lead renewed in (b) September 19th, 20th, 21st, and 24th. October 1st. Still no action visible in (b).	
3	September 15th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ .	September 19th. No action (a), (b), (c). Lead renewed in (b), (c) September 19th and 20th. September 21st. Still no action in (a). Action, however, commencing in (b), (c). September 28th. Still no action in (a), but action distinct in (b), (c), especially in (b).	
4	October 2nd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water $\frac{1}{2}$ neutralised with $\text{Na}_2\text{CO}_3$ . (e.) Same as (a), but water $\frac{1}{4}$ neutralised with $\text{Na}_2\text{CO}_3$ . (f.) Same as (a), but water $\frac{1}{8}$ neutralised with $\text{Na}_2\text{CO}_3$ .	October 4th, 1894. No action in any of the tubes. Lead renewed in all except (a). October 8th. Still no action; so lead renewed in all but (a). October 8th. Still no action, so lead renewed in all but (a). October 7th. Still no action in (a). Action, however, in all the other tubes. October 15th. Still no action in (c), distinct action in (b), action in (f), less in (e), still less in (d), and least in (c).	
5	October 23rd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ .	October 27th. No action visible in (a), (b). Lead removed, acid added to contents of tubes, and lead estimated.	(a.) = 1.5 (b.) = ? trace.
6	November 16th, 1894:— (a.) 10 c.c. Wakefield water before "treatment" in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water $\frac{1}{2}$ neutralised with $\text{Na}_2\text{CO}_3$ .	At first no action in any of the tubes, but gradually distinct action developed in (a), (b). December 11th. Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 15.0 (b.) = 17.5 (c.) = 0.5 (d.) = 1.0
7	November 24th, 1894:— (a.) 10 c.c. Dunford Reservoir water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ .	November 26th. No action in any of the tubes, so (b), (d) renewed lead. December 8th. Still no action visible in (a), (c), but very great action in (b), and slight action in (d). January 7th, 1895. Remarkably great action in (b). Lead removed, acid added, and amount of lead estimated.	(a.) = 3.0 (b.) = 100.0 (c.) = 1.0 (d.) = 10.0

TABLE XLV.—*continued.*

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
8	November 28th, 1894 :— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (e.) Same as (a), but twice as much $\text{Na}_2\text{CO}_3$ added to water as was necessary to neutralise. (f.) Same as (e).	November 29th and 30th. Lead renewed in (b), (d), (f). December 1st. No action in (a), (c), (e), (f). Action in (b), (d). Lead renewed in (f). December 1st, 2nd, 8rd, 4th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, and 15th. January 12th, 1895. Still no action apparent in (f). Action in (b), (d) distinct.	(a.) = 0·5 (b.) = 80·0 (c.) = 0·5 (d.) = 30·0 (e.) = 0·5 (f.) = 0·5
9	December 5th, 1894 :— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (e.) Same as (a), but twice as much $\text{Na}_2\text{CO}_3$ added to water as was necessary to neutralise. (f.) Same as (e).	December 6th and 7th. Lead renewed in (b), (d), (f). December 8th. Action now in (d), but none in (b), (f), so lead renewed in (b), (f). December 9th. Action now in (b), but still no action in (f), so lead renewed in (f). December 10th and 11th, lead again renewed in (f). January 14th, 1895. No action visible in (e), (e), (a). Distinct action in (b), (d). Very slight action in (f). Amount of lead estimated.	(a.) = 1·0 (b.) = 80·0 (c.) = Trace. (d.) = 40·0 (e.) = Trace. (f.) = 3·0
10	December 12th, 1894 :— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (e.) Same as (a), but twice as much $\text{Na}_2\text{CO}_3$ added to water as was necessary to neutralise. (f.) Same as (e).	December 18th. Lead renewed in (b), (d), (f). December 14th. Lead renewed in (a), (b), (c), (d), (e), (f). December 15th. Lead renewed in (f). January 9th, 1895. Slight action in (a). Great action in (b), slight in (d), and little or no action visible in (c), (e), (f).	(a.) 2·0 (b.) 80·0 (c.) Trace. (d.) 5·0 (e.) Trace (f.) 0·5
11	January 22nd, 1895 :— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but 5 c.c. Mossley water mixed with 5 c.c. XXX distilled water. (c.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (d.) Same as (c), but 5 c.c. neutralised Mossley water mixed with 5 c.c. XXX distilled water.	January 26th, 1895. Only traces of action visible. Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) Trace. (b.) 1·5 (c.) Trace. (d.) Trace.
12	January 31st, 1895 :— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. Mossley water + 5 c.c. XXX distilled water. (c.) Same as (a), but 1 per cent. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ added to the water (i.e., rather more than was necessary exactly to neutralise the acidity).	February 4th, 1895. No apparent action (a), (b), (c). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 0·5 (b.) = 1·0 (c.) = 0·0
13	January 31st, 1895 :— (a.) 10 c.c. Higher Swineshaw Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but water neutralised with $\text{Na}_2\text{CO}_3$ . (c.) Same as (b), but twice as much $\text{Na}_2\text{CO}_3$ added to the water as was necessary to neutralise.	February 7th, 1895. Distinct action in (a). No action apparently in (b), (c). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 10·0 (b.) = 1·0 (c.) = 0·5

TABLE XLV.—*continued.*

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
14	<p>May 17th, 1896:—</p> <p>(a.) 10 c.c. Watersheddells Reservoir water (after passing through filter beds) in test tube with lead <math>1 \times \frac{1}{4}</math>". The water was neutral.</p> <p>(b.) Same as (a.).</p> <p>(c.) Same as (a.), but 0.5 per cent. <math>\frac{1}{10}</math> <math>\text{Na}_2\text{CO}_3</math> added to the water.</p> <p>(d.) Same as (c.).</p>	<p>May 18th. Lead renewed in (b.).</p> <p>May 19th. Slight action now in (b.). Lead renewed in (d.). Lead renewed in (d) May 20th and 21st.</p> <p>May 23rd. No action visible in (a.), (c.), (d.), action, however, distinct in (b.). Amount of lead estimated.</p>	<p>(a.) = 0.5 (b.) = 15.0 (c.) = Trace. (d.) = 0.5</p>
15	<p>May 28th, 1896:—</p> <p>(a.) 10 c.c. Watersheddells Reservoir water (after passing through filter beds) in test tube with lead <math>1 \times \frac{1}{4}</math>". The water was neutral.</p> <p>(b.) Same as (a.).</p> <p>(c.) Same as (a.), but 0.3 per cent. <math>\frac{1}{10}</math> <math>\text{Na}_2\text{CO}_3</math> added to the water.</p> <p>(d.) Same as (c.).</p>	<p>May 29th. Lead renewed in (b.).</p> <p>(d.) May 30th, slight action in (b.), none in (d.). Lead renewed in (d) May 30th and 31st. June 5th. No action visible in (a.), little or no action in (c), very slight action in (d), very great action in (b.). Lead removed, acid added to contents of tube, and amount of lead estimated.</p>	<p>(a.) = 0.5 (b.) = 20.0 (c.) = Trace. (d.) = 1.5</p>

This table also emphasises the beneficial action of sodium carbonate as an inhibitor of the erosive power of various moorland waters. It also shows (*see* Experiments 14 and 15) that the addition of a small amount of sodium carbonate to a moorland water, which by "filtration treatment" has been transformed from an acid erosive water into a neutral non-erosive water, places it in a position remote from the possession of erosive ability.

TABLE XLVI.

Showing the EFFECT, as regards EROSION OF LEAD, of TREATING an ACID MOORLAND WATER (RINGSTONE RESERVOIR) with VARYING QUANTITIES of SODIUM CARBONATE  $\text{Na}_2\text{CO}_3$ .

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

Experiment.	Description of the Experiment.	Remarks.
1 (a.)	October 4th, 1894. 10 c.c. Ringstone Reservoir water (acid) in test tube with lead $1 \times \frac{1}{4}$ ". Wakefield Corporation Water-works.	October 5th. Slight action commencing in (a), no action visible in (b). Action beginning in (c) to (k), and apparently increasing in the order given in the table.
(b.)	Same as (a), but the water completely neutralised with $\text{Na}_2\text{CO}_3$ .	October 6th, 7th, 10th, 11th. Same remarks.
(c.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	October 15th. ? slight action in (d).
(d.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	October 17th. Distinct action in (a).
(e.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	? slight action in (b). Action in all the other tubes, and apparently least in (c) and greatest in (k). Thus the amount of erosion seemed to correspond with the amount of $\text{Na}_2\text{CO}_3$ present in the water, <i>i.e.</i> , where there was least $\text{Na}_2\text{CO}_3$ there was most erosion.
(f.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	
(g.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	
(h.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	
(i.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	
(j.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	
(k.)	Same as (a), but the water $\frac{1}{10}$ neutralised with $\text{Na}_2\text{CO}_3$ .	

This table (Table XLVI.) indicates that partial neutralisation with sodium carbonate, although it may diminish, does not remove the erosive power of Ringstone Reservoir water, and that complete neutralisation is needed to prevent altogether erosion from taking place. Judging from the foregoing tables, it may be added that probably a slight excess of sodium carbonate is needed to ensure a moorland water being really placed in a condition remote from the possession of erosive ability.

In the following table (Table XLVII.) the effect, as regards erosion of lead, of neutralising acid moorland waters with lime water is dealt with.

TABLE XLVII.

Showing the EFFECT, as regards EROSION of LEAD, of neutralising ACID MOORLAND WATERS with LIME WATER ( $\text{CaO}, \text{H}_2\text{O}$ ). Compare with Table OI.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (parts per 100,000).
1	October 9th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water first neutralised with lime water ( $\text{CaO}, \text{H}_2\text{O}$ ). (b <sup>1</sup> ) Same as (b).	October 10th, 11th, and 12th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). October 21st. No action visible in (a), (b); distinct action in (a <sup>1</sup> ), (b <sup>1</sup> ).	
2	October 16th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but the water neutralised with $\text{CaO}, \text{H}_2\text{O}$ . (h.) Same as (g). (i.) Same as (a), but the water $\frac{1}{2}$ neutralised with $\text{CaO}, \text{H}_2\text{O}$ . (j.) Same as (i).	October 17th. Lead renewed in (b), (h), (j). October 18th. No action in (a), (g), (i); none in (b), (h), (j); lead renewed in (h), (j). October 23rd. No action visible in (a), (g), (i), action however in (b), (h), (j).	
3	October 30th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ ". (d.) Same as (a), but the water neutralised with $\text{CaO}, \text{H}_2\text{O}$ . (e.) Same as (a), but the water $\frac{1}{2}$ neutralised with $\text{CaO}, \text{H}_2\text{O}$ . (f.) Same as (a), but the water $\frac{1}{2}$ neutralised with $\text{CaO}, \text{H}_2\text{O}$ .	November 8th. Distinct action in (a); no action visible in (d); distinct in (e), and only slight in (f). In this, as in all the other experiments, it was noted that although the $\text{CaO}, \text{H}_2\text{O}$ tended to prevent erosion, no protective coating seemed to be formed, the lead remaining quite bright. The amount of lead was estimated.	(a.) 10·0 (d.) 1·0 (e.) 12·5 (f.) 3·0
4	November 7th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but the water neutralised with $\text{CaO}, \text{H}_2\text{O}$ . (f.) Same as (c).	November 8th and 9th. Lead renewed in (b), (f). November 20th. No action apparent in (a), (c); action in (f), and enormous action in (b). The amount of lead was estimated.	(a.) 1·0 (b.) 50·0 (c.) 1·0 (f.) 5·0
5	November 16th, 1894:— (a.) 10 c.c. Ardsley water (before treatment) in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a). (c.) Same as (a), but the water neutralised with $\text{CaO}, \text{H}_2\text{O}$ . (f.) Same as (a), but the water $\frac{1}{2}$ neutralised with $\text{CaO}, \text{H}_2\text{O}$ .	December 8th. No action visible in (c). Distinct action in (a), (b). Action in (f), but not so great as in (a), (b). Amount of lead estimated.	(a.) 15·0 (b.) 17·5 (c.) 1·5 (f.) 7·0

TABLE XLVII.--continued.

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
6	November 24th, 1894:— (a.) 10 c.c. Dunford Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but the water neutralised with $\text{CaO}$ , $\text{H}_2\text{O}$ . (f.) Same as (c).	November 26th. Lead renewed in (b), (f). January 7th, 1895. No distinct action apparent in (a), (c). Enormous action in (b), (f). Amount of lead estimated.	(a.) 3'0 (b.) 100'0 (c.) 5'0 (f.) 70'0
7	December 4th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (g.) Same as (a), but the water neutralised with $\text{CaO}$ , $\text{H}_2\text{O}$ . (h.) Same as (g). (i.) Same as (a), but twice as much $\text{CaO}$ , $\text{H}_2\text{O}$ added to the water as was necessary to neutralise it. (j.) Same as (i).	December 5th, 1894. Lead renewed in (b), (h), (j). December 6th. Action beginning in (b), (h); no action, however, in (j), so lead renewed in (j). Lead renewed in (j) December 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, and 15th. January 14th, 1895. Action in (a). Very great action in (b). No action visible in (g). Very great action in (h). No action visible in (i), and none in (j), notwithstanding the frequent renewal of the lead. Amount of lead estimated.	(a.) 8'0 (b.) 60'0 (g.) 2'0 (h.) 60'0 (i.) 1'5 (j.) 1'0
8	December 11th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (k.) Same as (a), but the water neutralised with $\text{CaO}$ , $\text{H}_2\text{O}$ . (l.) Same as (k). (m.) Same as (a), but the water neutralised $\frac{1}{2}$ with $\text{CaO}$ , and $\frac{1}{2}$ with $\text{Na}_2\text{CO}_3$ . (n.) Same as (m).	December 12th. Lead renewed in (b), (l), (n). December 13th. Lead renewed in (b), (n). December 14th. Lead renewed in (n). December 15th. Lead again renewed in (n). January 10th, 1895. Slight action visible in (a), enormous action in (b), no action apparently in (k), some action in (l), none in (m), and none in (n). Amount of lead estimated.	(a.) 5'0 (b.) 120'0 (k.) 1'5 (l.) 10'0 (m.) 0'5 (n.) 1'0
9	December 12th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (i.) Same as (a), but the water neutralised with $\text{CaO}$ , $\text{H}_2\text{O}$ . (j.) Same as i. (k.) Same as (a), but twice as much $\text{CaO}$ , $\text{H}_2\text{O}$ added to the water as was necessary to neutralise. (l.) Same as (k).	December 13th. Lead renewed in (b), (j), (l). December 14th. Lead renewed in (b), (j), (l), (a), (i), (k). January 9th, 1895. Little or no action in (a), none visible in (i), (k), action in (b), (j), (l), but much greater in (b) than (j), and greater in (j) than (l). Amount of lead estimated.	(a.) 2'0 (b.) 60'0 (i.) Trace. (j.) 10'0 (k.) Trace. (l.) 5'0
10	February 20th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water neutralised with $\text{CaO}$ , $\text{H}_2\text{O}$ .	February 27th, 1895. No action visible in (a), (b). Amount of lead estimated.	(a.) 1'0 (b.) 0'5

It is to be noted that neutralisation with lime water, although inhibiting to a marked extent the erosive ability of acid moorland waters, does not seemingly allow the lead to become coated with a protective film, and does not as a rule place, to the same extent as does sodium carbonate, the waters in a condition remote from the possession of erosive ability.



Table XLVIII. shows the effect, as regards erosion of lead, of neutralising Shipley water with calcium bicarbonate.

TABLE XLVIII.

Showing the EFFECT, as regards EROSION of LEAD, of NEUTRALISING SHIPLEY WATER (an ACID MOORLAND WATER) with \*CALCIUM BICARBONATE ( $\text{CaCO}_3$ ,  $\text{H}_2\text{CO}_3$ ). Compare with Table XXXV. [Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ "') completely submerged.]

No.	Description of the Experiment.	Remarks.	Total Lead Salt (parts per 100,000).
1	February 20th, 1895:— (a) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ "'. (b) Same as (a), but the water first neutralised with *calcium bicarbonate ( $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ ).	February 27th. Little or no action visible in (a), (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 1.0 (b.) = Trace.
2	February 28th, 1895:— (a) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ "'. (b) Same as (a), but the water first neutralised with *calcium bicarbonate ( $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ ).	By March 7th erosion in (a), (b), and apparently greater in (b) than (a).	(a.) = 6.0 (b.) = 8.0
3	March 13th, 1895:— (a) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ "'. (b) Same as (a), but the water first neutralised with *calcium bicarbonate ( $\text{CaCO}_3$ , $\text{H}_2\text{CO}_3$ ).	By March 19th marked action in (a); none visible in (b).	(a.) = 10.0 (b.) = 1.0

\* Distilled water, saturated with  $\text{CO}_2$ , was shaken for some time with an excess of powdered Iceland spar and then filtered.

It will be seen that in Experiment 3, but not in Experiment 2, neutralisation with  $\text{CaCO}_3$ ,  $\text{H}_2\text{CO}_3$ , prevented erosion from taking place to any extent.

In the following tables (XLIX., L., LI., LII., LIII., LIV.) the effect, as regards erosion of lead, of filtering acid moorland waters through limestone, pclarite, asbestos, sand, flint, and marble is set forth in detail.

TABLE XLIX.

Showing the EFFECT, as regards EROSION of LEAD, of FILTERING certain ACID MOORLAND WATERS through LIMESTONE. Compare with Table CVIII.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ "') completely submerged.]

Experiment.	Description of the Experiment.	Hardness (Ost. O <sub>2</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
1	September 10th, 1894:— (a) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ "'. The same water as in Experiment 1 (a), Table CVIII. (b) Same as (a), but the water first filtered through limestone. The same water as in Experiment 1 (b), Table CVIII.	4.2  5.6	0.98  0.30	Erosion distinct in (a), (b), after a few days. By September 28th, 1894. Action very distinct.	

TABLE XLIX.—*continued.*

Experiment.	Description of the Experiment.	Hard- ness (CaCO <sub>3</sub> Parts per 100,000).	Aoidity in Terms of c.c. <sup>10</sup> Na <sup>+</sup> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
2	September 11th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead 1×½". The same water as in Experiment 2 (a), Table CVIII. (b.) Same as 1 (a), but the water first filtered through limestone. The same water as in Experiment 2 (b), Table CVIII.	3·8 3·8	0·42 Neutral	September 13th, 1894. No action in (a), (b), so fresh pieces of lead put in tubes. Erosion now commenced, and by September 28th was very pronounced in both (a) and (b).	
3	October 2nd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead 1×½". The same water as in Experiment 3 (a), Table CVIII. (b.) Same as (a), but the water first filtered through limestone. The same water as in Experiment 3 (b), Table CVIII.	3·2 3·9	0·48 Neutral	October 4th, 1894. No action in (a), (b), so lead renewed. On October 5th and 6th, again renewed. By October 10th action distinct in both (a) and (b).	
4	October 4th, 1894:— (a.) 10 c.c. Ringstone Reservoir water in test tube with lead 1×½". The same water as in Experiment 4 (a), Table CVIII. (b.) Same as (a), but the water first filtered through limestone. The same water as in Experiment 4 (b).	3·9 4·6	0·66 Neutral	October 7th, 1894. Action in (a), no action in (b), so lead renewed. October 18th, 1894. Action now distinct in (a), (b).	
5	October 10th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead 1×½". The same water as in Experiment 5 (a), Table CVIII. (a <sup>1</sup> .) Same as 5 (a). (b.) Same as 5 (a), but the water first filtered through limestone. The same water as in Experiment 5 (b), Table CVIII. (b <sup>1</sup> .) Same as 5 (b).	2·8 3·2	0·48 Neutral	October 10th, 1894. No action (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ), so lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). Lead again renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). October 12th and 13th. October 15th. Still no action in (a), (b), but action in (a <sup>1</sup> ), (b <sup>1</sup> ). October 21st. No action (a), (b); distinct action (a <sup>1</sup> ), (b <sup>1</sup> ).	
6	October 15th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1×½". The same water as in Experiment 6 (a), Table CVIII. (a <sup>1</sup> .) Same as 6 (a). (b.) Same as (a), but the water first filtered through limestone. The same water as in Experiment 6 (b), Table CVIII. (b <sup>1</sup> .) Same as 6 (b).	4·9 5·2	0·90 0·54	October 16th, 1894. Slight action in (a), (b), (a <sup>1</sup> ), (b <sup>1</sup> ). Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). October 21st. Distinct action in (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ), but greatest in (a <sup>1</sup> ), (b <sup>1</sup> ).	
7	October 23rd, 1894:— (a.) 10 c.c. Shipley water in tube with lead 1×½". (b.) Same as 7 (a), but the water first filtered once through 50 c.c. pea-size limestone, at rate of 30 secs. per 10 c.c.	— —	— —	October 27th, 1894. Action in (a), (b), (c); none visible in (d), (e). Lead removed, acid added, and amount of lead estimated.	(a.) 7·0 (b.) 7·0

TABLE XLIX.—*continued.*

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
7	October 23rd, 1894.— <i>cont.</i> (c.) Same as 7 (b), but the water filtered twice through the limestone. (d.) Same as 7 (b), but the water filtered five times through the limestone. (e.) Same as 7 (b), but the water filtered ten times through the limestone.	—	—		(c.) 2.0 (d.) 0.0 (e.) 0.0
8	October 26th, 1894:— (a.) 10 c.c. Graincliffe stream (acid feeder to Graincliffe Reservoir, Shipley Waterworks) in test tube with lead 1×½". (b.) Same as 8 (a), but the water first filtered through 50 c.c. limestone (pea size) at the rate of 30 secs. per 10 c.c. (c.) Same as 8 (b), but filtration repeated ten times.	—	—	October 31st, 1894. Action in (a), (b); none in (c). November 5th, 1894. Action in (a), (b); no action visible in (c). Lead removed, acid added, and amount of lead estimated.	(a.) 4.0 (b.) 4.0 (c.) 2.0
9	November 26th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1×½". The same water as in Experiment 7 (a), Table CVIII. (a <sup>1</sup> .) Same as 9 (a). (b.) Same as (a), but the water first filtered through limestone. The same water as in Experiment 7 (b), Table CVIII. (b <sup>1</sup> .) Same as 9 (b).	5.6 — 8.7 —	0.90 — Neutral —	November 26th, 1894. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). January 8th, 1895. Action in (a) distinct. Action in (b) slight. Distinct action in (b <sup>1</sup> ), and enormous action in (a <sup>1</sup> ). Lead removed, acid added, and amount of lead estimated.	(a.) 15.0 (a <sup>1</sup> .) 90.0 (b.) 2.5 (b <sup>1</sup> .) 25.0
10	November 28th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead 1×½". The same water as in Experiment 8 (a), Table CVIII. (a <sup>1</sup> .) Same as 10 (a). (b.) Same as (a), but the water first filtered through limestone. The same water as in Experiment 8 (b), Table CVIII. (b <sup>1</sup> .) Same as 10 (b).	3.5 — 4.2	0.30 — Neutral	November 29th, 1894. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). November 30th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). January 12th, 1895. No action visible in (a), (b). Action very great in (a <sup>1</sup> ), (b <sup>1</sup> ).	

The conditions of filtration, when not stated in the above table, are given in Table CVIII. It will be seen that filtration through limestone had the effect of hardening the water, reducing or neutralising the acidity, and inhibiting or preventing erosion from taking place. It ought, however, to be noted that the above treatment did not place the waters in a condition remote from the possession of erosive ability.

TABLE L.

Showing the EFFECT, as regards EROSION of LEAD, of FILTERING certain ACID MOORLAND WATERS through POLARITE. Compare with Table CVII.

[Bright sheet lead was used, and the pieces  $1 \times \frac{1}{4}$ " completely submerged.]

Experiment.	Description of the Experiment.	Hardness ( $\text{CaCO}_3$ Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
1	September 28th, 1894:— (a.) 10 c.c. Watersheddels Reservoir water in tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 1 (a), Table CVII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 1 (b), Table CVII.	2'50  2'50	0'48  Neutral	September 29th. Lead renewed in (a <sup>1</sup> ), (b). September 30th. Action in (a <sup>1</sup> ) and not in (b), so lead renewed in (b). Lead renewed in (b), October 1st. October 2nd, action now in (b). October 11th. No action in (a); action in (a <sup>1</sup> ) and (b), but action greater in (a <sup>1</sup> ) than (b), although the lead had been renewed more frequently in the latter.	
2	September 28th, 1894:— (a.) 10 c.c. water of acid peat feeder to Watersheddels Reservoir in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 2 (a), Table CVII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 2 (b), Table CVII.	2'50  2'50	0'60  Neutral	September 29th. Lead renewed in (a <sup>1</sup> ), (b). September 30th, action now commencing in (a <sup>1</sup> ), not in (b). Lead renewed in (b) October 1st and 2nd. October 11. Still no action in (b). Slight action in (a). Action distinct in (a <sup>1</sup> ).	
3	October 1st, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 3 (a), Table CVII. (b.) Same as (a), but the water first filtered slowly through polarite. The same water as in Experiment 3 (b.), Table CVII. (c.) Same as (a), but the water first filtered at a rapid rate through polarite. The same water as in Experiment 3 (c), Table CVII.	5'20  3'90  4'50	0'90  Neutral  0'66	October 2nd. No action in (b), (c), so lead renewed. October 6th. Action now in (a), (b), (c). October 15th. Distinct action in (a), (b), (c).	
4	October 1st, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 4 (a), Table CVII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 4 (b), Table CVII.	3'20  3'20	0'48  Neutral	Lead renewed in (a <sup>1</sup> ), (b), October 4th, 5th, and 6th. October 7th. Action in (a <sup>1</sup> ), (b), and none in (a). October 15th. Distinct action (a <sup>1</sup> ), (b), none in (a).	

TABLE L.—continued.

Experiment.	Description of the Experiment.	Hard- ness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. of $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
5	October 4th, 1894:— (a.) 10 c.c. Ringstone Re- servoir water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experi- ment 5 (a), Table CVII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 5 (b), Table CVII.	3'90 3'50	0'68 0'30	October 5th. Lead renewed in (a <sup>1</sup> ). October 6th, action commencing in (a), (a <sup>1</sup> ); none in (b). October 7th. Distinct ac- tion in (a), (a <sup>1</sup> ); none in (b), so lead renewed in (b). October 18th. Great action now in (a), (a <sup>1</sup> ), and (b).	
6	December 17th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 6 (a), Table CVII. (a <sup>1</sup> .) 5 c.c. of this water + 5 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 6 (b), Table CVII. (b <sup>1</sup> .) 5 c.c. of this water + 5 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ".	5'50 4'60 4'60	1'20 0'54 0'54	December 20th. Action dis- tinct in (a <sup>1</sup> ), (b <sup>1</sup> ). January 10th, 1895. Great action in (a <sup>1</sup> ), (b <sup>1</sup> ), little or no action in (b), slight action in (a). Lead re- moved, acid added, and amount of lead estimated.	(a.) 3'5 (a <sup>1</sup> .) 60'0 (b.) 0'5 (b <sup>1</sup> .) 40'0
7	May 17th, 1895:— (a.) 10 c.c. unfiltered Keigh- ley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experi- ment 7 (a), Table CVII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 7 (b), Table CVII. (b <sup>1</sup> .) Same as (b).	3'63 4'20	0'54 0'24	May 18th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), as no action. May 19th. Action now commencing in (a <sup>1</sup> ), (b <sup>1</sup> ). May 23rd. Action distinct in all the tubes. Lead removed, acid added, and amount of lead estimated.	(a.) 7'5 (a <sup>1</sup> .) 10'0 (b.) 5'0 (b <sup>1</sup> .) 15'0
8	May 21st, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 8 (a), Table CVII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experi- ment 8 (b), Table CVII. (b <sup>1</sup> .) Same as (b).	6'00 5'90	0'72 0'54	May 23rd. Renewed lead in (a <sup>1</sup> ), (b <sup>1</sup> ) as no action. May 24th. Slight action now in (a <sup>1</sup> ), (b <sup>1</sup> ). May 29th, distinct action in all the tubes, viz.: (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ). Lead re- moved, acid added, and amount of lead estimated.	(a.) 10'0 (a <sup>1</sup> .) 10'0 (b.) 5'0 (b <sup>1</sup> .) 10'0
9	May 30th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 9 (a), Table CVII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 9 (b), Table CVII. (b <sup>1</sup> .) Same as (b).	6'40 5'50	0'78 0'36	May 31st. Slight action in (a <sup>1</sup> ), (b <sup>1</sup> ), so lead not re- newed. June 7th, dis- tinct action in (a), (a <sup>1</sup> ), less action in (b), (b <sup>1</sup> ). Lead removed, acid added, and amount of lead estimated.	(a.) 10'0 (a <sup>1</sup> .) 10'0 (b.) 2'5 (b <sup>1</sup> .) 4'0

TABLE L.—*continued.*

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
10	June 6th, 1895:— (a.) 10 c.c. Shipley water in test tube, with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 10 (a), Table CVII. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water first filtered through polarite. The same water as in Experiment 10 (b), Table CVII. (b <sup>1</sup> ) Same as (b).	7.30  6.00	0.98  0.42	June 7th, 1895. Slight action in (a <sup>1</sup> ), so lead not renewed. No action in (b <sup>1</sup> ) so lead renewed. June 13th, now action very great in (b <sup>1</sup> ). Very slight action in (b), more in (a), (a <sup>1</sup> ). Lead removed, acid added, and amount of lead estimated.	(a.) 7.5  (a <sup>1</sup> ) 7.5 (b.) 1.5  (b <sup>1</sup> ) 20.0
11	June 8th, 1895:— (a.) 10 c.c. unfiltered Keighley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 11 (a), Table CVII. (a <sup>1</sup> ) Same as (a). (b.) The same as (a), but the water first filtered through polarite. The same water as in Experiment 11 (b), Table CVII. (b <sup>1</sup> ) Same as (b).	3.90  3.20	0.54  0.24	June 9th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). June 19th, little or no action visible in (a), (b). Action in (a <sup>1</sup> ), (b <sup>1</sup> ), but very much greater in (b <sup>1</sup> ) than (a <sup>1</sup> ). Lead removed, acid added, and amount of lead estimated.	(a.) 0.5  (a <sup>1</sup> ) 5.0 (b.) 0.5  (b <sup>1</sup> ) 45.0

The conditions of filtration, when not stated in the above table, are given in Table CVII. It is to be noted that filtration through polarite had usually the effect of softening the water somewhat, probably by partially neutralising the acidity. As regards erosion, the results were sometimes satisfactory, sometimes the reverse; but, as in the case of the limestone, the water was not placed by the treatment in a condition remote from the possession of erosive ability.

TABLE LI.

Showing the EFFECT, as regards EROSION of LEAD, of FILTERING ACID MOORLAND WATERS through ASBESTOS. Compare with Table CV.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

No.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
1	September 11th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 2 (a), Table CV. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 2 (b), Table CV.	0.42  0.36	September 13th. No action visible in (a), (a <sup>1</sup> ), (b). Lead renewed in (a <sup>1</sup> ), (b). September 14th. Action now in (a <sup>1</sup> ), (b). September 28th. Erosion now distinct in (a), (a <sup>1</sup> ), (b), but particularly in (a <sup>1</sup> ), (b).	

TABLE LI.—*continued.*

No.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
2	September 17th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first passed through an asbestos filter.	— —	By September 23th, distinct erosion in (a) and (b), and apparently the greatest action in (b).	
3	September 29th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first filtered four times slowly through an asbestos filter.	— —	By October 16th, erosion in (a) and (b), but in this experiment action was greatest in (a).	
4	October 26th, 1894:— (a.) 10 c.c. Black Dyke water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 3 (a), Table CV. (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 3 (b), Table CV.	1'20 1'02	October 31st. Erosion commencing in (a), (b). By November 5th erosion distinct in (a), (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 25'0 (b.) = 15'0
5	November 6th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 4 (a), Table CV. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 4 (b), Table CV. (b <sup>1</sup> ) Same as (b).	0'78 0'66	By November 20th action in (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ), but greatest in (a), (a <sup>1</sup> ). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 7'5 (a <sup>1</sup> ) = 7'5 (b.) = 2'5 (b <sup>1</sup> ) = 2'5
6	February 13th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 5 (a), Table CV. (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 5 (b), Table CV.	0'78 0'66	February 21st, 1895. No visible action in (a), (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 1'0 (b.) = 1'0
7	April 10th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 6 (a), Table CV. (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 6 (b), Table CV.	0'84 0'72	By April 16th distinct erosion in (b), slight action also in (a). Amount of lead estimated.	(a.) = 6'0 (b.) = 15'0
8	April 17th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 7 (a), Table CV. (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 7 (b), Table CV.	0'72 0'60	By April 22nd action in (a), (b), but less in (b) than (a). Amount of lead estimated.	(a.) = 7'5 (b.) = 3'0
9	April 24th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 8 (a), Table CV. (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 8 (b), Table CV.	0'78 0'66	By May 1st distinct action in (a), (b), and greater in (b) than (a). Amount of lead estimated.	(a.) = 10'0 (b.) = 12'5

TABLE LI.—continued.

No.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
10	May 1st, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 9 (a), Table CV. (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 9 (b), Table CV.	0.96 0.84	By May 8th distinct action in (a), (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 10.0 (b.) = 10.0
11	May 9th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 10 (a), Table CV. (b.) Same as (a), but the water first filtered through asbestos. The same water as in Experiment 10 (b), Table CV.	0.78 0.66	By May 15th action in (a), (b) and greater in (a) than (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 12.5 (b.) = 7.5

The conditions of filtration, when not stated in the above table, are given in Table OV. The filtration through asbestos did not reduce the acidity or the erosive ability of the various waters to any material extent; indeed in some cases erosion was more pronounced in the case of the water thus filtered.

TABLE LII.

Showing the EFFECT, as regards EROSION of LEAD, of FILTERING ACID MOORLAND WATERS through SAND. Compare with Table CIX.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ ") completely submerged.]

Experiment.	Description of the Experiment.	Hardness ( $\text{CaCO}_3$ Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
1	September 11th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 12 (a), Table CIX.  September 14th, 1894:— (b.) Same as (a), but the water first filtered through Gullane sea sand. The same water as in Experiment 12 (b), Table CIX.	2.5 9.8	0.42 Neutral	By September 21st, no action visible in (a), so lead renewed. By September 26th action distinct in (a).  September 16th. No action in (b), so lead renewed. September 17th. Still no action in (b), so lead again renewed. September 26th. Now action decided in (b).	



TABLE LII.—*continued.*

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ N <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
2	<p>September 19th, 1894:— (a.) 10 c.c. Wakefield "untreated" water from Ardsley Reservoir after filtration through Gullane sea sand in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 13 (b), Table CIX.</p> <p>(b.) Same as (a), but the sand was previously treated with HCl. to dissolve out calcareous matters, &amp;c. The same water as in Experiment 13 (c), Table CIX.</p>	6.0	Neutral	September 20th. No action visible in (a), (b), so lead renewed. By October 1st action very great in both (a) and (b), and action apparently greater in (b) than (a).	
3	<p>September 26th, 1894:— (a.) 10 c.c. Shipley water (after filtration through Gullane sea sand) in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 16 (b), Table CIX.</p> <p>(b.) Same as (a), but the sand was previously treated with HCl. The same water as in Experiment 16 (c), Table CIX.</p>	5.6	0.42	September 27th. No action (a), (b), so lead renewed. September 28th. Action commencing in (a), (b). October 15th. Great action in (a), (b), and greater in (b) than (a).	
4	<p>September 26th, 1894:— (a.) 10 c.c. Mossley water (after filtration through Gullane sea sand) in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 17 (b), Table CIX.</p> <p>(b.) Same as (a), but the sand was previously treated with HCl. The same water as in Experiment 17 (c), Table CIX.</p>	5.3	0.84		
5	<p>September 26th, 1894:— (a.) 10 c.c. Mossley water (after filtration through Gullane sea sand) in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 17 (b), Table CIX.</p> <p>(b.) Same as (a), but the sand was previously treated with HCl. The same water as in Experiment 17 (c), Table CIX.</p>	3.6	Neutral	Lead renewed in (a), (b), as no action September 27th, 28th, and 30th. October 15th. Action now decided in both (a) and (b), and greater in (b) than (a).	
6	<p>October 8th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 18 (a), Table CIX.</p> <p>(a<sup>1</sup>). Same as (a).</p> <p>(b.) Same as (a), but the water was first filtered through Shipley sandstone sand. The same water as in Experiment 18 (b), Table CIX.</p> <p>(b<sup>1</sup>). Same as (b).</p> <p>(c.) Same as (a), but the water was first filtered through Gullane sea sand. The same water as in Experiment 18 (c), Table CIX.</p> <p>(c<sup>1</sup>). Same as (c).</p>	5.3	1.08	October 9th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). October 10th. Action now commencing in (a <sup>1</sup> ), (b <sup>1</sup> ), but not in (c <sup>1</sup> ), so lead renewed in (c <sup>1</sup> ). By October 21st, distinct action in (a), (a <sup>1</sup> ), but greatest in (a <sup>1</sup> ). Distinct action in (b), (b <sup>1</sup> ), but greatest in (b <sup>1</sup> ). No action visible in (c) and only slight action in (c <sup>1</sup> ).	
7	<p>October 10th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 19 (a), Table CIX.</p> <p>(a<sup>1</sup>). Same as (a).</p>	2.8	0.48	October 11th, 12th, and 13th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). October 21st. No action visible in (a), (b), but distinct action in (a <sup>1</sup> ), (b <sup>1</sup> ).	

TABLE LII.—continued.

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ N <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
6	October 10th, 1894— <i>cont.</i> (b.) Same as (a), but the water was first filtered through Gullane sea sand. The same water as in Experiment 19 (b), Table CIX. (b <sup>1</sup> .) Same as (b).	4.1	Neutral		
7	October 16th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead 1 × 4". The same water as in Experiment 20 (a), Table CIX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water was first filtered through Gullane sea sand. The same water as in Experiment 20 (b), Table CIX. (b <sup>1</sup> .) Same as (b). (c.) Same as (a), but the water was first filtered through sea sand previously treated with HCl. The same water as in Experiment 20 (c), Table CIX. (c <sup>1</sup> .) Same as (c).	2.8 5.6 2.8	0.42 Neutral. 0.24	October 17th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). October 21st. No action in (a), (b), (c). Action in (b <sup>1</sup> ). No action in (a <sup>1</sup> ), (c <sup>1</sup> ). Lead renewed in (a <sup>1</sup> ), (c <sup>1</sup> ). October 23rd. Still no action in (a), (b), (c), action, however, distinct in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ).	
8	November 13th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1 × 4". The same water as in Experiment 21 (a), Table CIX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water was first filtered through Gullane sea sand. The same water as in Experiment 21 (b), Table CIX. (b <sup>1</sup> .) Same as (b). (c.) Same as (a), but the water was first filtered through sea sand previously treated with HCl. The same water as in Experiment 21 (c), Table CIX. (c <sup>1</sup> .) Same as (c).	5.9 9.8 5.5	1.02 Neutral. 0.78	December 1st. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). December 2nd. Action commencing in (a <sup>1</sup> ), (c <sup>1</sup> ), but not in (b <sup>1</sup> ), so lead renewed in (b <sup>1</sup> ). December 4th and 8th. Lead again renewed in (b <sup>1</sup> ). January 5th, 1895. No action visible in (b), (b <sup>1</sup> ). Slight action in (a), (c), and greater in (a) than (c). Enormous action in (a <sup>1</sup> ), (c <sup>1</sup> ), and greater in (a <sup>1</sup> ) than (c <sup>1</sup> ). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 10.0 (a <sup>1</sup> .) 100.0 (b.) 1.0 (b <sup>1</sup> .) 1.0 (c.) 4.0 (c <sup>1</sup> .) 60.0
9	November 20th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1 × 4". The same water as in Experiment 22 (a), Table CIX. (See Plate XIII.) (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water was first filtered through Shipley sandstone sand. The same water as in Experiment 22 (b), Table CIX. (b <sup>1</sup> .) Same as (b). (c.) Same as (b), but the rate of filtration slower, and a greater thickness of sand used. The same water as in Experiment 22 (c), Table CIX. (c <sup>1</sup> .) Same as (c).	6.2 6.2 6.0	1.08 0.96 0.96	January 5th, 1895. Decided action in all the tubes. Action in (a), (a <sup>1</sup> ) greater than in (b), (b <sup>1</sup> ), and (c), (c <sup>1</sup> ). Amount of lead estimated in (a), (b), (c).	(a.) 30.0 (b.) 20.0 (c.) 20.0

TABLE LII.—continued.

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Alkalinity in Terms of c.c. of $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the water.	Remarks.	Total Lead Salt (Parts per 100,000).
10	November 27th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1 × 1". The same water as in Experiment 23 (a), Table CIX. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water was first filtered through Shipley sandstone sand. The same water as in Experiment 23 (b), Table CIX. (b <sup>1</sup> ) Same as (b).	5.6 5.3	0.9 0.6	November 28th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). November 30th. Slight action in (a), (b), distinct action in (a <sup>1</sup> ), (b <sup>1</sup> ). January 5th, 1895. Very slight action in (b), distinct in (a), and enormous action in (a <sup>1</sup> ), (b <sup>1</sup> ), but greater in (a <sup>1</sup> ) than (b <sup>1</sup> ). Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) 15.0 (a <sup>1</sup> ) 90.0 (b.) 2.0 (b <sup>1</sup> ) 50.0
11	December 11th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1 × 1". The same water as in Experiment 24 (a), Table CIX. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water was first filtered through Gullane sea sand. The same water as in Experiment 24 (b), Table CIX. (b <sup>1</sup> ) Same as (b). (c) Same as (b), but the sand previously treated with HCl. The same water as in Experiment 24 (c), Table CIX. (c <sup>1</sup> ) Same as (c).	6.0 9.1 5.8	0.96 Neutral. 0.54	December 12th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). December 13th. Action commencing in (c <sup>1</sup> ). No apparent action in (a <sup>1</sup> ), (b <sup>1</sup> ). Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). December 14th. No action visible in (b <sup>1</sup> ). Action in (a <sup>1</sup> ). Lead renewed in (b <sup>1</sup> ). December 15th. Great action in (a <sup>1</sup> ), (c <sup>1</sup> ). January 10th, 1895. Enormous action in (a <sup>1</sup> ), (c <sup>1</sup> ). No action apparently in (b), (b <sup>1</sup> ), and only slight action in (a), (c). Amount of lead estimated.	(a.) 5.0 (a <sup>1</sup> ) 120.0 (b.) Trace. (b <sup>1</sup> ) 1.0 (c) 7.5 (c <sup>1</sup> ) 100.0
12	January 9th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead 1 × 1". The same water as in Experiment 10 (a), Table CIX. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water was first filtered through With river sand. The same water as in Experiment 10 (b), Table CIX. (b <sup>1</sup> ) Same as (b).	4.9 5.3	0.9 Trace.	January 10th, 1895. Lead renewed in (b <sup>1</sup> ), (a <sup>1</sup> ). January 15th. Action considerable in (b <sup>1</sup> ), action also in (a), (a <sup>1</sup> ), (b), but not so well marked. Amount of lead estimated.	(a.) 2.5 (a <sup>1</sup> ) 1.0 (b.) 5.0 (b <sup>1</sup> ) 20.0
13	January 15th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead 1 × 1". (a <sup>1</sup> ) 5 c.c. of the same water + 5 c.c. distilled water. (b.) Same as (a), but the water was first filtered slowly through river sand. (b <sup>1</sup> ) 5 c.c. of the same water + 5 c.c. XXX distilled water. (c.) Same as (b), but sea sand employed. (c <sup>1</sup> ) 5 c.c. of the same water + 5 c.c. XXX distilled water.	—	—	January 15th. Slight action in (a), action in (a <sup>1</sup> ), (b <sup>1</sup> ), no action visible in (b), (c), (c <sup>1</sup> ). Amount of lead estimated.	(a.) 5.0 (a <sup>1</sup> ) 10.0 (b.) 1.5 (b <sup>1</sup> ) 20.0 (c.) Trace. (c <sup>1</sup> ) Trace.

TABLE LII.—continued.

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ N <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
16	May 22nd, 1895:— (a.) 10 c.c. Shipley water in test tube with lead 1×4". The same water as in Experiment 25 (a), Table CIX. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water was first filtered through Keighley sandstone sand. The same water as in Experiment 25 (b), Table CIX. (b <sup>1</sup> ) Same as (b).	6·0  6·2	0·73  0·66	May 23rd. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). May 29th. Distinct action in all the tubes. Amount of lead estimated.	(a.) 10·0  (a <sup>1</sup> ) 10·0 (b.) 10·0  (b <sup>1</sup> ) 15·0
15	May 28th, 1895:— (a.) 10 c.c. Keighley water in test tube with lead 1×4". The same water as in Experiment 26 (a), Table CIX. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water was first filtered through Keighley sandstone sand. The same water as in Experiment 26 (b), Table CIX. (b <sup>1</sup> ) Same as (b).	3·3  3·6	0·48  0·42	May 29th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). June 8th. Action in (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ), and least in (b). Amount of lead estimated.	(a.) 10·0  (a <sup>1</sup> ) 20·0 (b.) 2·5  (b <sup>1</sup> ) 20·0
16	May 30th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead 1×4". The same water as in Experiment 27 (a), Table CIX. (a <sup>1</sup> ) Same as (a). (b.) Same as (a), but the water was first filtered through Keighley sandstone sand. The same water as in Experiment 27 (b), Table CIX. (b <sup>1</sup> ) Same as (b).	6·4  5·7	0·78  0·54	May 31st. Slight action in (a <sup>1</sup> ), no action visible in (b <sup>1</sup> ), so lead renewed in (b). June 7th. Action in (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ), and greatest in (b <sup>1</sup> ). Amount of lead estimated.	(a.) 10·0  (a <sup>1</sup> ) 10·0 (b.) 10·0  (b <sup>1</sup> ) 20·0
17	June 5th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead 1×4". The same water as in Experiment 28 (a), Table CIX. (a <sup>1</sup> ) Same as (a). (b.) Same as (a) but the water was first filtered through Keighley sandstone sand. The same water as in Experiment 28 (b), Table CIX. (b <sup>1</sup> ) Same as (b).	7·3  6·9	0·96  0·72	June 7th. Action apparently commencing in (a <sup>1</sup> ), so lead not renewed. No action visible, however, in (b <sup>1</sup> ), so lead renewed. June 12th. Action now very marked in (b <sup>1</sup> ), action also in (a), (a <sup>1</sup> ), no action visible in (b). Amount of lead estimated.	(a.) 7·0  (a <sup>1</sup> ) 7·5 (b.) 1·5  (b <sup>1</sup> ) 20·0
18	September 10th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1×4". The same water as in Experiment 11 (a), Table CIX. (b.) Same as (a), but the water was first filtered through Gullane sea sand. The same water as in Experiment 11 (b), Table CIX.	—	—	September 11th, 13th, 14th, and 15th, lead renewed in (b), as no action. By September 13th action in (a), so lead not renewed. September 28th. Action only slight in (b) distinct in (a).	

The conditions of filtration, when not stated in the foregoing table, are given in table CIX. It is somewhat difficult to summarise this table, as sea sand, sandstone sand, river sand, and sometimes sand previously treated with HCl (and then with distilled water) to dissolve out the calcareous matters were employed. The sea sand usually had the effect of hardening the water and neutralising the acidity; but when the sand was first treated with HCl, a slight softening effect was produced and the water retained its acidity. As regards erosion, in the first case (untreated sand) erosion was inhibited, and sometimes the water was even placed in a condition remote from the possession of erosive ability; in the latter case (HCl treated sand) the results were usually unsatisfactory. The sandstone sand usually had the effect of slightly softening the water and reducing, but not neutralising, the acidity. As regards erosion, the results were commonly of an unsatisfactory nature, the water either retaining, in full or in some measure, its original erosive power and not acquiring as the result of the filtration any special plumbo-protective ability (Plate XVIII., Fig. 21). The same remarks apply to the river sand.

TABLE LIII.

Showing the EFFECTS, as regards EROSION of LEAD, of the FILTRATION of certain ACID MOORLAND WATERS through FLINT. Compare with Table CXII.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ N <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
1	January 23th, 1895 :— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 1 (a), Table CXII.	4.9	1.02	February 2nd 1895. Distinct action in (a), slight action in (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 15.0
	(b.) Same as (a), but the water first filtered through flint. The same water as in Experiment 1 (b), Table CXII.	4.9	0.84		(b.) 4.0
2	January 30th, 1895 :— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 2 (a), Table CXII.	5.4	0.96	February 4th, 1895. Action in (a), (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 7.5
	(b.) Same as (a), but the water first filtered through flint. The same water as in Experiment 2 (b), Table CXII.	5.4	0.84		(b.) 5.0
3	January 31st, 1895 :— (a.) 10 c.c. Higher Swinshaw Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 3 (a), Table CXII.	3.4	0.48	February 7th, 1895. Action in (a), no visible action in (b). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 10.0
	(b.) Same as (a), but the water first filtered through flint. The same water as in Experiment 3 (b), Table CXII.	3.2	0.42		(b.) 1.5

TABLE LIII.—continued.

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
4	February 6th, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a), but the water first filtered through 50 c.c. flint (pea size) in burette ( $\frac{7}{8}$ inch diam.), at rate of 45 secs. per 10 c.c. Filtration repeated 6 times.	5.5 5.5	0.86 0.84	February 12th, 1895. Action in (a), (b), greater in (a) than (b). Amount of lead estimated.	(a.) 4.0 (b.) 2.0

The conditions of filtration, when not stated in the above table, will be found in Table CXII. It will be noted that the filtration through flint did not appreciably alter the hardness or reduce the acidity to any material extent. Erosion was not prevented, although the degree of action was inhibited to some extent by the filtration.

TABLE LIV.

Showing the EFFECT, as regards EROSION OF LEAD, of FILTERING certain ACID MOORLAND WATERS through MARBLE. Compare with Table CX.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ "') completely submerged.]

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
1	September 29th, 1894:— (a.) 10 c.c. Watersheddels Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 16 (a), Table CX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water was filtered repeatedly through marble until the filtrate ceased to give an acid reaction. The same water as in Experiment 16 (b), Table CX.	2.5 3.2	0.48 Neutral	September 30th. Lead renewed in (a <sup>1</sup> ), (b). October 11th. Distinct action in (a <sup>1</sup> ), (b). No action visible in (a). Action in (b) apparently greater than in (a <sup>1</sup> ).	

TABLE LIV.—continued.

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
2	September 29th, 1894:— (a.) 10 c.c. water of acid peat feeder to Watersheddells Reservoir (No. 13) in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 17 (a), Table CX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water was first filtered through marble until the filtrate ceased to give an acid reaction. The same water as in Experiment 17 (b), Table CX.	2.5  3.5	0.6  Neutral	September 30th. Lead renewed in (a <sup>1</sup> ), (b). Lead again renewed in (b) October 1st and 2nd. October 11th. Very slight action in (a). Action in (a <sup>1</sup> ). No action apparently in (b).	
3	September 30th, 1894:— (a.) 10 c.c. Watersheddells Reservoir water (after very slow filtration through marble) in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 16 (c), Table CX.	3.8	Neutral	October 1st. Lead renewed in (a). October 2nd. Distinct action in (a). October 11th. Action in (a) comparable to action in (b), Experiment 1.	
4	October 4th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 19 (a), Table CX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through marble. The same water as in Experiment 19 (b), Table CX.	3.2  3.8	0.48  Neutral	Lead renewed on three consecutive days in (a <sup>1</sup> ), (b). October 15th. No action visible in (a), distinct action in (a <sup>1</sup> ), (b).	
5	October 4th, 1894:— (a.) 10 c.c. Ringstone Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 20 (a), Table CX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through marble. The same water as in Experiment 20 (b), Table CX.	3.9  4.3	0.68  Neutral	October 5th. Lead renewed in (a <sup>1</sup> ). October 7th. Lead renewed in (b). October 18th. Distinct action in (a), (a <sup>1</sup> ), (b).	
6	October 9th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 21 (a), Table CX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through marble. The same water as in Experiment 21 (b), Table CX. (b <sup>1</sup> .) Same as (b).	2.8  3.3	0.48  Neutral	Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), October 10th, 11th, 12th. October 15th. Action now in (a <sup>1</sup> ), none in (b <sup>1</sup> ), so lead renewed in (b <sup>1</sup> ). October 18th. Action now in (a <sup>1</sup> ), (b <sup>1</sup> ). October 21st. No action in (a), (b), but distinct action in (a <sup>1</sup> ), (b <sup>1</sup> ).	

TABLE LIV.—continued.

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
7	October 15th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1×4". The same water as in Experiment 23 (a), Table CX. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through marble. The same water as in Experiment 23 (b), Table CX. (b <sup>1</sup> .) Same as (b).	4·9 5·0	0·00 0·54	October 16th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). October 21st. Action in (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ), and greatest in (a <sup>1</sup> ), (b <sup>1</sup> ).	
8	January 22nd, 1895:— (a.) 10 c.c. Shipley water in test tube with lead 1×4". The same water as in Experiment 24 (a), Table CX. (a <sup>1</sup> .) 5 c.c. Shipley water + 5 c.c. XXX distilled water. (b.) Same as (a), but the water first filtered through marble. The same water as in Experiment 24 (b), Table CX. (b <sup>1</sup> .) 5 c.c. of the same water as in (b), + 5 c.c. XXX distilled water.	4·9 6·0	1·02 Neutral	January 23th, 1895. Distinct action in (a), little or no action in (b), very great action in (a <sup>1</sup> ), (b <sup>1</sup> ), especially the latter. Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 51·0 (a <sup>1</sup> .) 30·0 (b.) 2·0 (b <sup>1</sup> .) 50·0
9	October 2nd, 1894:— (a.) 10 c.c. Shipley water in test tube with lead 1×4". The same water as in Experiment 18 (a), Table CX. (b.) Same as (a), but the water first filtered through marble. The same water as in Experiment 18 (b), Table CX. (c.) Same as (b), but rate of filtration slower. The same water as in Experiment 18 (c), Table CX.	5·2 5·4 5·6	0·9 — Neutral	By October 15th, 1894, very great action in (a), (b), (c).	

The conditions of filtration, when not stated in the above table, will be found in 'Table CX.' The effect of the filtration of the acid moorland waters through marble was to render the waters "harder" and to neutralise or, at all events, greatly to reduce the acidity. The results as regards erosion of lead were not always satisfactory; and the filtration through marble failed to place the waters in a condition remote from the possession of erosive ability.

In the following table (Table LV.) the effect, as regards erosion of lead, of the addition to various acid moorland waters of measured quantities of silica (SiO<sub>2</sub>) is shown.



TABLE LV.

Showing the EFFECT, as regards EROSION of LEAD, of the ADDITION to various ACID MOORLAND WATERS of MEASURED QUANTITIES of \*SILICA ( $\text{SiO}_2$ ). †Compare with Table XCVIII.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ "') completely submerged.]

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
1	October 31st, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ ". The same water as in Experiment 1(a), Table XCVIII. (b.) Same as (a), but the water first shaken with excess $\text{SiO}_2$ . The same water as in Experiment 1 (b), Table XCVIII.	1.00 0.78	November 8th. Action in (a), (b), but greater in (a) than (b). Amount of lead estimated.	(a.) = 10.0 (b.) = 4.0
2	November 6th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ ". The same water as in Experiment 3(a), Table XCVIII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess $\text{SiO}_2$ . The same water as in Experiment 3 (b), Table XCVIII. (b <sup>1</sup> .) Same as (b).	1.02 0.78	November 20th. Action in (a), (a <sup>1</sup> ). Only very slight action in (b), (b <sup>1</sup> ). Amount of lead estimated.	(a.) = 7.5 (a <sup>1</sup> .) = 7.5 (b.) = 2.5 (b <sup>1</sup> .) = 2.5
3	November 7th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". The same water as in Experiment 4 (a), Table XCVIII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess $\text{SiO}_2$ . The same water as in Experiment 4 (b), Table XCVIII. (b <sup>1</sup> .) Same as (a).	0.42 0.30	November 8th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). November 9th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). November 10th. Action commencing in (a <sup>1</sup> ); no action visible in (a), (b), (b <sup>1</sup> ). November 20th. Enormous action in (a <sup>1</sup> ); no action visible in (a), (b), (b <sup>1</sup> ). Amount of lead estimated.	(a.) = 1.0 (a <sup>1</sup> .) = 100.0 (b.) = 1.0 (b <sup>1</sup> .) = 1.0
4	November 8th, 1894:— (a.) 10 c.c. Kingstone Reservoir water in test tube with lead $1 \times \frac{1}{2}$ ". The same water as in Experiment 5 (a), Table XCVIII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess $\text{SiO}_2$ . The same water as in Experiment 5 (b), Table XCVIII. (b <sup>1</sup> .) Same as (b).	0.96 0.66	November 10th. Action apparently just beginning in (a), (a <sup>1</sup> ), (b), (b <sup>1</sup> ). November 20th. Distinct action in (a), action also in (a <sup>1</sup> ), (b), (b <sup>1</sup> ). Amount of lead estimated in (a <sup>1</sup> ), (b <sup>1</sup> ). January 12th, 1895. Amount of lead estimated in (a), (b).	(a.) = 30.0 (a <sup>1</sup> .) = 15.0 (b.) = 15.0 (b <sup>1</sup> .) = 10.0

\* An excess of silica ( $\text{SiO}_2$ ) was added in each case, viz.: 0.1 per cent.

† The first part of each separate experiment is referred to as (a), and the second part is referred to as (b) in this table.

TABLE LV.—*continued.*

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Remarks.	Total Lead Salt (Parts per 100,000).
5	November 8th, 1894:— (a.) 10 c.c. Lowmoor catch-water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 6 (a), Table XCVIII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess $\text{SiO}_2$ . The same water as in Experiment 6 (b), Table XCVIII. (b <sup>1</sup> .) Same as (b).	0·80  0·30	November 10th and 11th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). November 20th. Distinct action in (a <sup>1</sup> ), little or no action in (a), (b), (b <sup>1</sup> ). Amount of lead estimated.	(a.) = 2·0  a <sup>1</sup> . = 12·5 (b.) = 1·5  (b <sup>1</sup> .) = 1·5
6	November 14th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 7 (a), Table XCVIII. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess $\text{SiO}_2$ . The same water as in Experiment 7 (b), Table XCVIII. (b <sup>1</sup> .) Same as (b).	1·02  0·84	December 1. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). January 5, 1895. Action in (a), (b), and greater in (a) than (b). Enormous action in (a <sup>1</sup> ), (b <sup>1</sup> ), especially in (a <sup>1</sup> ). Amount of lead estimated.	(a.) = 10·0  a <sup>1</sup> . = 100·0 (b.) = 6·0  (b <sup>1</sup> .) = 80·0
7	January 16th, 1895:— (a.) 10 c.c. Shipley water (after filtration through filter paper) in test tube with lead $1 \times \frac{1}{4}$ ". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess $\text{SiO}_2$ , and then filtered through filter paper. (b <sup>1</sup> .) Same as (b).	—  —	January 17th and 18th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). January 22nd. Considerable action in (a <sup>1</sup> ), (b <sup>1</sup> ), less in (a), and least of all in (b). Amount of lead estimated.	(a.) = 10·0  a <sup>1</sup> . = 20·0 (b.) = 1·0  (b <sup>1</sup> .) = 20·0

For further information as to the conditions of experiment reference must be made to Table XCVIII. The results seem to show that the addition of silica to the various waters reduced to some extent their acidity and modified their erosive ability; but not to such an extent as to place the waters in a "safe" condition as regards erosive ability.

In the following table (Table LVI.) the effect, as regards erosion of lead, of the addition to an acid moorland water of calcium phosphate and sodium phosphate is set forth in detail

TABLE LVI.

Showing the ACTION, as regards EROSION OF LEAD, of the ADDITION to SHIPLEY WATER (an ACID MOORLAND WATER), of MEASURED QUANTITIES of (a) CALCIUM PHOSPHATE and (b) SODIUM PHOSPHATE. Compare with Table XCVI.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of the Experiment.	Reaction.	Remarks.	Total Lead Salt (Parts per 100,000).
1	December 11th, 1894 :— (a.) 10 c.c. Shipley water after filtration through filter paper in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) The same water shaken with 0.5 per cent. sodium phosphate and filtered through filter paper. 10 c.c. in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c). (e.) Same as (c), but calcium phosphate used. (f.) Same as (e).	Acid Neutral " " "	December 12th. Lead renewed in (b), (d), (f). December 13. No action visible in (a), (b), but apparently action in (c), (d). No action in (e), (f). Lead renewed in (b), (f). December 18th. Action now distinct in (b). Lead renewed in (d) and (f). December 20th. Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 1.5 (b.) = 10.0 (c.) = Trace. (d.) = Trace. (e.) = 1.0 (f.) = 1.5
2	December 18th, 1894 :— (a.) 10 c.c. Shipley water after filtration through filter paper in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. of the same water + 5 c.c. XXX distilled water in test tube with lead $1 \times \frac{1}{4}$ ". (c.) As in (c) Experiment 1; but only 0.1 per cent. sodium phosphate used. (d.) As in (c) Experiment 1; but the water diluted a half with XXX distilled water as in (b) Experiment 2. (e.) As in (e) Experiment 1; but only 0.1 per cent. calcium phosphate used. (f.) As in (e) Experiment 1; but the water diluted a half with XXX distilled water as in (b) Experiment 2.	Acid " Neutral " " "	December 20th. Action in (b), apparently none in (a), (c), (d), (e), (f). January 10th, 1895. Slight action in (a), action in (b). No action visible in (c), (d), (e), (f). Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) = 3.0 (b.) = 6.0 (c.) = 0.5 (d.) = 0.5 (e.) = 0.5 (f.) = 1.0
3	March 20th, 1895 :— (a.) 10 c.c. Shipley water after filtration through filter paper in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (c) Experiment 1; but only 0.1 per cent. sodium phosphate used. (c.) Same as (e) Experiment 1; but only 0.1 per cent. calcium phosphate used.	Acid Neutral "	March 26th, 1895. No action visible in (b), (c), slight action in (a). Lead removed, acid added to contents of tubes, and lead estimated.	(a.) = 4.0 (b.) = 0.0 (c.) = 0.5
4	March 26th, 1895 :— (a.) 10 c.c. Shipley water after filtration through filter paper in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (c) Experiment 1; but only 0.1 per cent. sodium phosphate used. (c.) Same as (e) Experiment 1; but only 0.1 per cent. calcium phosphate used.	Acid Neutral "	April 2nd. Distinct action in (a), none in (b), (c). Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) = 10.0 (b.) = Trace. (c.) = Trace.

TABLE LVI.—*continued.*

No.	Description of the Experiment.	Reaction.	Remarks.	Total Lead Salt (Parts per 100,000).
5	April 4th, 1895:— (a.) 10 c.c. Shipley water after filtration through filter paper in test tube with lead $1 \times \frac{1}{4}$ ".	Acid	April 10th. Distinct action in (a), none in (b), (c). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) = 7.5
	(b.) Same as (c) Experiment 1; but only 0.1 per cent. sodium phosphate used.	Neutral		(b.) = Traces.
	(c.) Same as (d) Experiment 1; but only 0.1 per cent. calcium phosphate used.	"		(c.) = Traces.
6	April 10th, 1895:— (a.) 10 c.c. Shipley water after filtration through filter paper in test tube with lead $1 \times \frac{1}{4}$ ".	Acid	April 16th. Distinct action in (a), none in (b), (c). Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) = 15.0
	(b.) Same as (c) Experiment 1; but only 0.1 per cent. sodium phosphate used.	Neutral		(b.) = Trace.
	(c.) Same as (e) Experiment 1; but only 0.1 per cent. calcium phosphate used.	"		(c.) = Trace.

It will be seen that the addition of both calcium phosphate and sodium phosphate to Shipley water had a decided influence in inhibiting erosion.

The effect, as regards erosion of lead, of the action of Shipley water upon alloys of lead and tin is shown in the following table (Table LVII.).

TABLE LVII.

Showing the EFFECT, as regards EROSION of LEAD, of the ACTION of SHIPLEY WATER (an ACID MOORLAND WATER) upon ALLOYS of LEAD and TIN. Compare with Table XIV.

[Brightsheet lead used and the pieces ( $1 \times \frac{1}{2}$ " ) completely submerged.]

No.	Description of Experiment.	Remarks.	Total Lead Salt (Parts per 100,000).
1	February 23rd, 1895:— (a.) 10 c.c. Shipley water (acid) in test tube with lead $1 \times \frac{1}{4}$ ".	By February 27th. Slight action visible in (a), little or no action apparently in (b), (c), (d), (e). Amount of lead estimated.	(a.) = 6.0
	(b.) Same as (a), but alloy of lead with 2 per cent. tin.		(b.) = 2.5
	(c.) Same as (a), but alloy of lead with 4 per cent. tin.		(c.) = 2.0
	(d.) Same as (a), but alloy of lead with 6 per cent. tin.		(d.) = 2.5
	(e.) Same as (a), but alloy of lead with 10 per cent. tin.		(e.) = 2.0
2	February 28th, 1895:— (a.) 10 c.c. Shipley water (acid) in test tube with lead $1 \times \frac{1}{4}$ ".	By March 7th, 1895, erosion visible in all the tubes. Lead removed, acid added to contents of tubes and amount of lead estimated.	(a.) = 6.0
	(b.) Same as (a), but alloy of lead with 2 per cent. tin.		(b.) = 8.0
	(c.) Same as (a), but alloy of lead with 4 per cent. tin.		(c.) = 7.0
	(d.) Same as (a), but alloy of lead with 6 per cent. tin.		(d.) = 7.0
	(e.) Same as (a), but alloy of lead with 10 per cent. tin.		(e.) = 7.0

Judging by the results of the second experiment, it would not seem as if alloys of lead and tin could be relied on to prevent erosion.

In the following table (Table LVIII.) the effect, as regards erosion of lead, of the addition to certain acid moorland waters of each of the following substances:—Powdered limestone, chalk, polarite, Iceland spar, marble, and flint is set forth in detail.

TABLE LVIII.

Showing the EFFECT, as regards EROSION of LEAD, of the ADDITION to certain ACID MOORLAND WATERS severally of the following substances:—POWDERED LIMESTONE, CHALK, POLARITE, ICELAND SPAR, MARBLE, and FLINT. Compare with Table CII.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ ") completely submerged.]

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction.	Remarks.	Total Lead Salt (Parts per 100,000).
1	September 10th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a), but the water first shaken with an excess of powdered limestone, allowed to settle and then carefully decanted. (c.) Same as (b), but powdered chalk.	— 14.0 —	Acid Neutral "	September 13th. Action commencing in (a), no action in (b), (c). Lead renewed in (b), (c), September 13th, 14th, 16th, 17th, 18th, and 21st. September 23th. Action distinct in (a), no action visible in (b), (c), notwithstanding the renewal of the pieces of lead.	
2	September 19th, 1894:— (a.) 10 c.c. Wakefield water (before "treatment") shaken with excess powdered chalk, allowed to settle and then carefully decanted, in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a), but powdered limestone.	— —	" "	Lead renewed in (a), (b), September 20th, 21st, and 24th. October 1st still no action (a), (b).	
3	September 19th, 1894:— (a.) Same as (a) Experiment 2, but Higher Swineshaw Reservoir water used. (b.) Same as (b) Experiment 2, but Higher Swineshaw Reservoir water used.	— —	" "	Lead renewed in (a), (b), September 20th and 21st. September 24th. Slight action in (a), none in (b), so lead renewed in (b). October 1st. Still no action in (b), and only very slight action in (a).	
4	October 9th, 1894:— (a.) Shipley water (shaken with excess powdered chalk, allowed to settle and then carefully decanted). 10 c.c. in test tube with lead $1 \times \frac{1}{2}$ ". (b.) Same as (a).	12.6 —	" "	Lead renewed in (b) October 10th, 11th, 15th, and 18th. October 21st. Still no action in (a), (b).	
5	October 9th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess chalk (powdered), allowed to settle, and then carefully decanted. (b <sup>1</sup> .) Same as (b).	2.8 9.1	Acid Neutral	Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), October 10th, 11th, and 13th. October 15th. Lead again renewed in (b <sup>1</sup> ). October 21st. No action in (a), but action in (a <sup>1</sup> ). No action in (b), and only very slight action in (b <sup>1</sup> ).	
6	October 16th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess powdered chalk, allowed to settle, and then carefully decanted. (b <sup>1</sup> .) Same as (b).	— —	Acid Neutral	October 17th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). October 18th. Lead again renewed in (b <sup>1</sup> ). October 23rd. No action in (a), (b), but action in (a <sup>1</sup> ), (b <sup>1</sup> ). Action in (b <sup>1</sup> ) only slight in amount.	

TABLE LVIII.—*continued.*

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction.	Remarks.	Total Salt Lead (Parts per 100,000).
7	November 7th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead 1×¼". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with excess powdered chalk, allowed to settle, and then carefully decanted. (b <sup>1</sup> .) Same as (b).	3·8 6·7	Acid Neutral	Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), October 8th and 9th. November 20th. Very great action in (a <sup>1</sup> ), no action visible in (a), (b), and only slight action in (b <sup>1</sup> ). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 1·0 (a <sup>1</sup> .) 50·0 (b.) 0·5 (b <sup>1</sup> .) 20·0
8	January 16th, 1895:— (a.) 10 c.c. Shipley water (after filtration) in test tube with lead 1×¼". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first shaken with 0·1 per cent. powdered limestone and then filtered. (b <sup>1</sup> .) Same as (b). (c.) Same as (b), but powdered polarite (0·1 per cent.) replaced the limestone. (c <sup>1</sup> .) Same as (c). (d.) Same as (b), but powdered chalk (0·1 per cent.) replaced the limestone. (d <sup>1</sup> .) Same as (d).	— — — — — — —	Acid Neutral Acid Neutral	January 17th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ), (d <sup>1</sup> ). January 18th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ), (d <sup>1</sup> ). January 19th. Lead renewed in (b <sup>1</sup> ), (d <sup>1</sup> ). January 21st. Lead renewed in (b <sup>1</sup> ), (d <sup>1</sup> ). January 22nd. Action distinct in (a), very slight action in (c), no action in (b), (d). Great action in (a <sup>1</sup> ), (c <sup>1</sup> ), and none visible in (b <sup>1</sup> ), (d <sup>1</sup> ). Lead removed from tubes, acid added, and amount of lead estimated.	(a.) 10·0 (a <sup>1</sup> .) 20·0 (b.) 0·0 (b <sup>1</sup> .) 0·5 (c.) 2·5 (c <sup>1</sup> .) 30·0 (d.) 0·0 (d <sup>1</sup> .) 0·5
9	January 23th, 1895:— (a.) 10 c.c. Shipley water (after being shaken with 0·1 per cent. powdered flint, and then filtered) in test tube with lead 1×¼". (b.) Same as (a), but 0·1 per cent. Ireland spar.	— —	Acid Neutral	February 2nd. Action distinct in (a), no action in (b). Amount of lead estimated.	(a.) 10·0 (b.) 0·5
10	January 30th, 1895:— (a.) 10 c.c. Shipley water (after being shaken with 0·1 per cent. powdered flint and then filtered) in test tube with lead 1×¼". (b.) Same as (a), but 0·1 per cent. Iceland Spar (powdered) replaced the flint. (c.) Same as (a), but 0·1 per cent. marble (powdered) replaced the flint. (d.) Same as (a), but 0·1 per cent. chalk (powdered) replaced the flint. (e.) Same as (a), but 0·1 per cent. limestone (powdered) replaced the flint. (f.) 10 c.c. Shipley water (filtered) in test tube with lead 1×¼".	— — — — — — —	Acid Neutral " " " Acid	February 4th, 1895. No action visible in (b), (c), (d), (e). Action in (a) and very slight action in (f). Amount of lead estimated.	(a.) 7·5 (b.) 0·5 (c.) 0·5 (d.) 0·5 (e.) 0·5 (f.) 2·0
11	October 4th, 1894:— (a.) 10 c.c. Ringstone Reservoir water in test tube with lead 1×¼". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water shaken with an excess of chalk powder and then filtered.	— — —	" Neutral	October 5th. Lead renewed in (a <sup>1</sup> ). October 6th. Action in (a), (a <sup>1</sup> ); none in (b). October 7th, 8th, 10th, 11th, 12th, and 16th, lead renewed in (b) as no action. October 18th. Decided action in (a), (a <sup>1</sup> ), and only slight in (b).	

Speaking in general terms, the results showed that the use of limestone, chalk, Iceland Spar, and marble neutralised the acidity of the various acid waters, inhibited erosion, and, indeed, usually placed the waters in a condition remote from the possession of erosive ability. Polarite and flint failed as regards neutralising the acidity of the waters, and were unsatisfactory in inhibiting erosion.

In Table LIX. the effect, as regards erosion of lead, of the addition to acid moorland waters of various salts is shown.

TABLE LIX.

Showing the EFFECT, as regards EROSION of LEAD, of the addition to certain ACID MOORLAND WATERS of MEASURED QUANTITIES of each of the following substances :—Magnesium Sulphate ( $\text{MgSO}_4$ ); Potassium Nitrate ( $\text{KNO}_3$ ); Ammonium Nitrate ( $\text{NH}_4\text{NO}_3$ ); Sodium Nitrate ( $\text{NaNO}_3$ ); Sodium Nitrite ( $\text{NaNO}_2$ ); Potassium Nitrite ( $\text{KNO}_2$ ); Ammonium Chloride ( $\text{NH}_4\text{Cl}$ ); Sodium Chloride ( $\text{NaCl}$ ); Calcium Sulphate ( $\text{CaSO}_4$ ); and Sodium Sulphate ( $\text{Na}_2\text{SO}_4$ ). Compare with Tables LXXXVIII., LXXXIX., XC., XCII., XCIII., XCIV., and XCV.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{4}$ " ) completely submerged.]

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
1	October 23rd, 1894 :— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water + 0.1 per cent. $\text{MgSO}_4$ in test tube with lead $1 \times \frac{1}{4}$ ".	October 27th. Action in (a), (b). Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) 6.6 (b.) 8.5
2	December 11th, 1894 :— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water + 0.1 per cent. $\text{MgSO}_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (c.) Same as (a). (d.) Same as (b).	December 12th. Lead renewed in (c), (d). December 13th. Lead again renewed in (c), (d). December 14th. Action now distinct in (c), (d). January 10th, 1895. Action enormous in (c). Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 5.0 (b.) 2.0 (c.) 120.0 (d.) 5.0
3	December 12th, 1894 :— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) The same water as in (a) + 0.1 per cent. $\text{MgSO}_4$ in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c).	December 13th. Lead renewed in (b), (d). December 14th. Lead again renewed in (b), (d). December 15th. Action now in (b), but none in (d), so lead renewed in (d). January 9th, 1895. No action visible in (c), slight action apparently in (a), (d). Great action in (b). Amount of lead estimated.	(a.) 2.0 (b.) 60.0 (c.) Traces. (d.) 5.0
4	January 15th, 1895 :— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. of same water as in (a) + 5 c.c. XXX distilled water. (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{MgSO}_4$ . (d.) 5 c.c. of same water as in (c) + 5 c.c. XXX distilled water.	January 19th. Slight action in all the tubes. Lead removed, acid added to contents of tubes, and amount of lead estimated.	(a.) 5.0 (b.) 5.0 (c.) 4.0 (d.) 8.0
5	January 15th, 1895 :— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. of same water as in (a) + 5 c.c. XXX distilled water. (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{MgSO}_4$ . (d.) 5 c.c. of same water as in (c) + 5 c.c. XXX distilled water.	January 19th. No apparent action in (a), (c), very slight in (b), (d). Amount of lead estimated.	(a.) 0.5 (b.) 6.0 (c.) 0.5 (d.) 2.0

TABLE LIX.—continued.

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
6	October 20th, 1894:— (a.) 10 c.c. Higher Swineshaw Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.) (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{KNO}_3$ . (d.) Same as (c.)	October 21st. Lead renewed in (b), (d). October 22nd. Lead again renewed in (b), (d). October 23rd. Action in (d); no action in (b), so lead renewed. October 27th. No visible action in (a), (c), distinct action in (b), (d). Amount of lead estimated.	(a.) 1.0 (b.) 20.0 (c.) 2.0 (d.) 40.0
7	October 23rd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{KNO}_3$ .	October 27th. Little or no action in (a), (b). Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) 1.5 (b.) 2.5
8	November 27th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.) (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{KNO}_3$ . (d.) Same as (c.)	November 29th. Lead renewed in (b), (d). January 5th, 1895. Action in (a), (c), but greater in (c) than (a). Enormous action in (b), (d), and greater in (d) than (b).	(a.) 15.0 (b.) 90.0 (c.) 35.0 (d.) 130.0
9	October 9th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.) (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{NO}_3$ . (d.) Same as (c.)	October 10th. Lead renewed in (b), (d). Lead again renewed in (b). October 11th and 12th. October 21st. Action in (b), no apparent action in (a), great action in (c), (d), especially the latter.	
10*	October 20th, 1894:— (a.) 10 c.c. Brushes Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.) (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{NO}_3$ . (d.) Same as (c.)	October 21st. Lead renewed in (b), (d). Lead again renewed in (b), October 22nd and 23rd. October 27th. No action in (a), distinct action in (b), enormous action in (c), (d). Amount of lead estimated.	(a.) Trace. (b.) 25.0 (c.) 100.0 (d.) 100.0
11	October 23rd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{NO}_3$ .	October 27th. No action visible in (a), but action in (b). Amount of lead estimated.	(a.) 1.5 (b.) 25.0
12	October 30th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{NO}_3$ .	November 3rd. No action visible in (a). Action in (b) distinct.	
13	November 13th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.) (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{NO}_3$ . (d.) Same as (c.)	November 16th. No action visible in (a), (b); action, however, in (c), (d). Amount of lead estimated.	(a.) 0.5 (b.) 0.5 (c.) 12.5 (d.) 13.5
14	November 20th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a.) (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{NO}_3$ . (d.) Same as (c.)	November 26th. No action visible in (a), (b); action, however, marked in (c), (d). Amount of lead estimated.	(a.) 0.5 (b.) 0.5 (c.) 35.0 (d.) 40.0

\* With the exception of Experiment 10, all the waters were acid.



TABLE LIX.—*continued*.

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
15	January 16th, 1895:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. of same water as in (a) + 5 c.c. XXX distilled water. (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{NO}_3$ . (d.) 5 c.c. of same water as in (c) + 5 c.c. XXX distilled water.	January 18th, 1895. No action visible in (a); slight action in (b); considerable action in (c), (d). Amount of lead estimated.	(a.) 0.5 (b.) 6.0 (c.) 30.0 (d.) 30.0
16	October 16th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NaNO}_3$ . (d.) Same as (c).	October 17th. Lead renewed in (b), (d). October 18th. Action beginning in (d). Lead renewed in (b). October 23rd. No action visible in (a), (c); action, however, in (b), (d).	
17	October 20th, 1894:— (a.) 10 c.c. Lower Swineshaw Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NaNO}_3$ . (d.) Same as (c).	October 21st and 22nd. Lead renewed in (b), (d). October 23rd. Action commencing in (b), (d). October 27th, no action visible in (a), (c); distinct action, however, in (b), (d), and especially in (d). Amount of lead estimated.	(a.) 1.5 (b.) 30.0 (c.) 3.0 (d.) 90.0
18	October 23rd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NaNO}_3$ .	October 27th. Very slight action in (a), (b). Amount of lead estimated.	(a.) 1.5 (b.) 2.5
19	October 16th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NaNO}_3$ . (d.) Same as (c).	October 17th. Lead renewed in (b), (d). October 21st, lead again renewed in (b), but not in (d), as action commencing. No apparent action in (a), (c). October 23rd, no action visible in (a), (c); action distinct in (b), (d).	
20	October 20th, 1894:— (a.) 10 c.c. Yeoman Hey Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NaNO}_3$ . (d.) Same as (c).	October 21st. Lead renewed in (b), (d). By October 27th action in (a), (b), (c), (d). Least in (a), more action in (b), still more in (c), and greatest in (d).	
21	October 23rd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a) + 0.1 per cent. $\text{NaNO}_3$ . (c.) Same as (a) + 0.1 per cent. $\text{KNO}_3$ .	October 27th. Little or no action in (a), slight action in (b), (c) apparently.	
22	October 16th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{Cl}$ . (d.) Same as (c).	October 17th. Lead renewed in (b), (d). October 21st. Lead again renewed in (b), (d). October 23rd. Action (b), (d), but greater in (b) than (d). Apparently no action in (a), (c).	
23	October 23rd, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{Cl}$ .	October 27th. Action in (a), (b). Lead removed, acid added to contents of tube, and amount of lead estimated.	(a.) 6.6 (b.) 6.6

TABLE LIX.—*continued.*

No.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
24	January 22nd, 1895:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 5 c.c. of same water as in (a) + 5 c.c. XXX distilled water. (c.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{Cl}$ . (d.) 5 c.c. of same water as in (c) + 5 c.c. XXX distilled water.	January 25th, 1895. Distinct action in (a), slight action in (c), great action in (b), (d), but greater in (b) than (d). Amount of lead estimated.	(a.) 15.0 (b.) 50.0 (c.) 8.0 (d.) 15.0
25	January 31st, 1895:— (a.) 10 c.c. Higher Swineshaw Reservoir water in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NH}_4\text{Cl}$ .	February 7th, 1895. Action in both (a) and (b). Amount of lead estimated.	(a.) 10.0 (b.) 10.0
26	October 23rd, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (d.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{NaCl}$ .	October 27th. Action in (a), (b), but greater in (a) than (b). Amount of lead estimated.	(a.) 6.6 (b.) 3.3
27	October 23rd, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water as in (a), but the water was first saturated with $\text{CaSO}_4$ (excess $\text{CaSO}_4$ added to the water, shaken for some time, allowed to settle, and then decanted).	By October 27th action both in (a) and (b). Amount of lead estimated.	(a.) 6.6 (b.) 6.6
28	November 27th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) Same as (a), but the water saturated with $\text{CaSO}_4$ . (d.) Same as (c).	November 28th. Lead renewed in (b), (d). November 30th. Slight action commencing in (a), (c), distinct action in (b), (d). January 5th, 1895. Distinct action in (a), less in (c). Very great action in (b), (d), especially the former. Amount of lead estimated.	(a.) 15.0 (b.) 90.0 (c.) 5.0 (d.) 20.0
29	January 16th, 1895:— (a.) 10 c.c. Shipley water (after filtration through filter paper) in test tube with lead $1 \times \frac{1}{4}$ ". (b.) Same as (a). (c.) 10 c.c. Shipley water (after being shaken with 0.1 per cent. $\text{CaSO}_4$ and filtered through filter paper) in test tube with lead $1 \times \frac{1}{4}$ ". (d.) Same as (c).	Lead renewed in (b), (d). January 17th and 18th. January 22nd. Action in all the tubes, greatest in (b), then (a), then (d), and least in (c). Amount of lead estimated.	(a.) 10.0 (b.) 20.0 (c.) 2.5 (d.) 7.0
30	September 10th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. Shipley water (after being shaken with excess $\text{CaSO}_4$ for some time and then filtered through filter paper) in test tube with lead $1 \times \frac{1}{4}$ ".	By September 28th, 1894, action in both (a) and (b), and apparently as much action in (b) as (a).	
31	October 23rd, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". (b.) 10 c.c. of same water as in (a) + 0.1 per cent. $\text{Na}_2\text{SO}_4$ .	By October 27th little or no action visible in (a), (b).	(a.) 1.5 (b.) 1.5

Speaking in general terms, the sulphates and chlorides do not seem to have exercised a very pronounced or uniform influence in any direction; but on the whole they appeared to have an inhibitory action, whilst the nitrites and nitrates (particularly ammonium nitrate) actually increased the erosive action on lead of the waters dealt with in these experiments.

In Table LX. the effect, as regards erosion of lead, of filtering certain acid moorland waters through chalk, marble, Iceland spar, coke, and limestone is shown.

TABLE LX.

Showing the EFFECT, as regards EROSION of LEAD, of FILTERING certain ACID MOORLAND WATERS through CHALK, MARBLE, ICELAND SPAR, COKE, and LIMESTONE.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ "') completely submerged.]

Experiment.	Description of the Experiment.	Hardness ( $\text{CaCO}_3$ Parts per 100,000.)	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
1	October 15th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ " the same water as in experiment 2 (a), Table CXI. (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through chalk. The same water as in Experiment 2 (b), Table CXI. (b <sup>1</sup> .) Same as (b).	4.9  6.4	0.90  0.48	October 16th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). October 21st. Action in all the tubes, but greater in (a <sup>1</sup> ), (b <sup>1</sup> ), than (a), (b). Action in (a) and (b) about the same in amount. Action in (a <sup>1</sup> ), (b <sup>1</sup> ) about the same.	
2	December 4th, 1894:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{2}$ ". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first filtered through 50 c.c. marble (pea size), in burette ( $\frac{3}{4}$ " diam.), at the rate of $1\frac{1}{2}$ mins. per 10 c.c. (b <sup>1</sup> .) Same as (b). (c.) Same as (b), but the water first saturated with $\text{CO}_2$ , and then filtered twice through the marble at the above rate. (c <sup>1</sup> .) Same as (c).	5.4  6.7  35.0	0.84  Neutral  ? Trace acid.	December 5th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). December 6th. Action commencing in (a <sup>1</sup> ), (b <sup>1</sup> ). Lead renewed in (c <sup>1</sup> ) December 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, and 15th. January 14th, 1895. Slight action in (a); very great action in (a <sup>1</sup> ), (b <sup>1</sup> ); no action in (b), (c), and no action in (c <sup>1</sup> ), notwithstanding the frequent renewal of the pieces of lead. Amount of lead estimated.	(a.) 8.0 (a <sup>1</sup> .) 60.0 (b.) 1.0  (b <sup>1</sup> .) 60.0 (c.) 1.5  (c <sup>1</sup> .) 0.3
3	December 5th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{2}$ ". (a <sup>1</sup> .) Same as (a). (b.) Same as (a), but the water first saturated with $\text{CO}_2$ , and then filtered twice through 50 c.c. marble (pea size), in burette ( $\frac{1}{2}$ " in diam.), at rate of $1\frac{1}{2}$ mins. per 10 c.c. (b <sup>1</sup> .) Same as (b). (c.) Same as (b). (c <sup>1</sup> .) Same as (b).	4.1  22.4	0.30  Neutral	December 6th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). December 7th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). December 8th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ), (c <sup>1</sup> ). December 9th. Action had now commenced in (a <sup>1</sup> ), none in (b <sup>1</sup> ), (c <sup>1</sup> ), so lead renewed in (b <sup>1</sup> ), (c <sup>1</sup> ). December 10th, 11th, 12th, 13th, 14th, and 15th, lead renewed in (b <sup>1</sup> ), (c <sup>1</sup> ). January 14th, 1895. No action visible in (a), (b), (b <sup>1</sup> ), (c), (c <sup>1</sup> ). Action very great in (a <sup>1</sup> ). Amount of lead estimated.	(a.) 1.0 (a <sup>1</sup> .) 80.0 (b.) Trace.  (b <sup>1</sup> .) Trace. (c.) Trace. (c <sup>1</sup> .) Trace.

TABLE LX.—*continued.*

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{N}{10}$ -Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
4	<p>January 22nd, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 24 (a), Table CX.</p> <p>(a<sup>1</sup>.) 5 c.c. of the same water as in (a) + 5 c.c. XXX distilled water.</p> <p>(b.) Same as (a), but the water first filtered through marble. The same water as in Experiment 24 (b), Table CX.</p> <p>(b<sup>1</sup>.) 5 c.c. of the same water as in (b) + 5 c.c. XXX distilled water.</p> <p>(c.) Same as (b), but half the amount of Na<sub>2</sub>CO<sub>3</sub> added to the water as was necessary to neutralise the original acidity, i.e., the acidity of the water in (a).</p> <p>(c<sup>1</sup>.) 5 c.c. of the same water as in (c) + 5 c.c. XXX distilled water.</p>	4·9	1·02	<p>January 26th, 1895. Dis- tinct action in (a); no action in (b), (c). Great action in (a<sup>1</sup>), (b<sup>1</sup>); trace in (c<sup>1</sup>). Lead re- moved, acid added to contents of tubes, and amount of lead esti- mated.</p>	<p>(a.) 15·0</p> <p>(a<sup>1</sup>.) 80·0</p> <p>(b.) 2·0</p> <p>(b<sup>1</sup>.) 50·0</p> <p>(c.) 0·5</p> <p>(c<sup>1</sup>.) 2·0</p>
5	<p>January 28th, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 7(a), Table CIV.</p> <p>(b.) Same as (a), but the water first filtered through Iceland spar. The same water as in Experiment 7 (b), Table CIV.</p>	4·9	1·02	<p>January 29th. Distinct action in (a), (b). Amount of lead esti- mated.</p>	<p>(a.) 15·0</p> <p>(b.) 10·0</p>
6	<p>January 30th, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 8(a), Table CIV.</p> <p>(b.) Same as (a), but the water first filtered through Iceland spar. The same water as in Experiment 8(b), Table CIV.</p>	5·4	0·96	<p>February 4th, 1895. Action in (a), none visible in (b). Amount of lead estimated.</p>	<p>(a.) 7·5</p> <p>(b.) 1·0</p>
7	<p>May 16th, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 6(a), Table CVI.</p> <p>(b.) Same as (a), but the water first filtered through coke. The same water as in Experiment 6(b), Table CVI.</p>	5·74	0·78	<p>May 21st. No action visible in (b), slight action in (a). Lead re- moved, acid added to contents of tubes, and amount of lead esti- mated.</p>	<p>(a.) 6·0</p> <p>(b.) 1·0</p>

TABLE LX.—continued.

Experiment.	Description of the Experiment.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Acidity in Terms of c.c. $\frac{x}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
8	May 15th, 1898:— (a.) 10 c.c. Shipley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 7(a). (a <sup>1</sup> .) Same as (a). (b.) Same as Experiment 7(b). (b <sup>1</sup> .) Same as (b).	—	—	May 16th. Lead renewed in (a <sup>1</sup> ), (b <sup>1</sup> ). May 17th. Action now commencing in (a <sup>1</sup> ), (b <sup>1</sup> ). May 20th. Action in (a), (a <sup>1</sup> ); very slight action in (b), and distinct action in (b <sup>1</sup> ), and greater than in case of (a <sup>1</sup> ). Amount of lead estimated.	(a.) 4.0  (a <sup>1</sup> .) 5.0 (b.) 2.0 (b <sup>1</sup> .) 8.0
9	November 28th, 1894:— (a.) 10 c.c. Mossley water in test tube with lead $1 \times \frac{1}{4}$ ". The same water as in Experiment 8(a), Table CVIII. (b.) Same as (a). (c.) Same as (a), but the water first filtered through limestone. The same water as in Experiment 8(b), Table CVIII. (d.) Same as (c). (e.) Same as (c), but a neutralising quantity of Na <sub>2</sub> CO <sub>3</sub> added to the water, i.e., as much Na <sub>2</sub> CO <sub>3</sub> was added as was necessary to neutralise untreated Mossley water. (f.) Same as (e).	3.5  4.2	0.30  Neutral	November 29th and 30th. Lead renewed in (b), (d), (f). January 12th, 1895. No action visible in (a), (c), (e). Slight action in (f), very great action in (b), (d), especially the former. Amount of lead estimated.	(a.) 0.5  (b.) 80.0 (c.) 0.5  (d.) 40.0 (e.) 0.5  (f.) 5.0

In Experiment 1, filtration through chalk did not, as regards inhibition of erosion, produce a satisfactory result. In Experiment 2, filtration through marble reduced the erosive power of Shipley water, but failed to place it in a position remote from the possession of erosive ability. But when the water, previous to filtration through marble was saturated with CO<sub>2</sub>, its hardness was greatly increased, and repeated renewal of the lead failed to induce erosion. Experiment 3, as regards Mossley water, yielded parallel results; inasmuch as hardening the water by saturation with CO<sub>2</sub>, and then filtration through marble, placed the treated water in a condition remote from possession of erosive ability. Experiment 4 is of interest as it seems to show that a water neutralised by filtration through marble, but still possessing a tendency to erode lead, may be rendered less liable to do so by the addition of a minute amount of sodium carbonate. In Experiment 5, Shipley water, after filtration through Iceland spar, by no means lost its power of eroding lead. In Experiment 6, however, the results were much more satisfactory. Experiments 7 and 8, considered together, do not seem to show that filtration through coke could be relied on to place a moorland water (e.g., Shipley water) on the safe side as regards erosion. Experiment 9 goes to show that, after filtration through such a substance as limestone, it would be advantageous to supplement the filtration treatment with the addition in small amount of sodium carbonate.

In the following table (Table LXI.) the effects, as regards erosion of lead, of placing acid moorland waters under various conditions is given.

TABLE LXI.

Showing the EFFECT, as regards EROSION of LEAD, of placing ACID MOORLAND WATERS under the various conditions specified in the Table.

[Bright sheet lead was used, and the pieces ( $1 \times \frac{1}{2}$ "') completely submerged.]

Experiment.	Description of the Experiment.	Remarks as to Erosion.	Total Lead Salt (Parts per 100,000).
1	<p>October 23rd, 1894:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) Same as (a) + 0.1 per cent. Settle water (a hard limestone water).</p> <p>(c.) Same as (a) + 1.0 per cent. Settle water (a hard limestone water).</p> <p>(d.) same as (a) + 10.0 per cent. Settle water (a hard limestone water).</p>	<p>October 27th. Action in (a), (b), (c); no action apparent in (d). Lead removed, acid added to contents of tubes, and amount of lead estimated.</p>	<p>(a.) 6.6</p> <p>(b.) 9.9</p> <p>(c.) 9.9</p> <p>(d.) Trace</p>
2	<p>October 26th, 1894:—</p> <p>(a.) 10 c.c. Graincliffe stream water (Shipley Waterworks) in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) Same as (a), but the water first heated to 100° C. for quarter of an hour, and then allowed to cool and re-absorb oxygen.</p> <p>(c.) 10 c.c. Blackdyke stream (Shipley Waterworks) in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(d.) Same as (c), but the water first heated to 100° C. for quarter of an hour, and then allowed to cool and re-absorb oxygen.</p>	<p>November 5th. Action in (a), (b), (c), (d). Lead removed, acid added to contents of tubes, and amount of lead estimated.</p>	<p>(a.) 4.0</p> <p>(b.) 10.0</p> <p>(c.) 25.0</p> <p>(d.) 10.0</p>
3	<p>October 30th, 1894:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(b.) 50 c.c. Shipley water evaporated to dryness in platinum crucible and residue dissolved in 50 c.c. distilled water (distillate of Shipley water). 10 c.c. in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(c.) Same as (b), but residue ignited.</p>	<p>October 31st. Action distinct in (b), (c).</p> <p>November 5th. Action in (a), but greater action in (b), (c).</p> <p>November 8th. Distinct action in (a); enormous action in (b), (c). Amount of lead estimated.</p>	<p>(a.) 10.0</p> <p>(b.) 80.0</p> <p>(c.) 80.0</p>
4	<p>November 14th, 1894:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(a<sup>1</sup>.) Same as (a).</p> <p>(b.) 10 c.c. Shipley water in test tube with coated lead <math>1 \times \frac{1}{4}</math>" (the coating was obtained by leaving bright sheet lead in contact with Settle water, a hard limestone water, overnight, and then washing with distilled water and allowing to dry). Cf. Table XLIII.</p> <p>(b<sup>1</sup>.) Same as (b).</p> <p>(c.) Same as (a), but the water first heated to 100° C. for a quarter of an hour and then allowed to cool and re-absorb oxygen.</p> <p>(c<sup>1</sup>.) Same as (c).</p>	<p>December 1st. Lead renewed in (a<sup>1</sup>), (c<sup>1</sup>).</p> <p>By January 8th, 1895, distinct action in (a), slight action in (b), (b<sup>1</sup>), (c), enormous action in (a<sup>1</sup>), (c<sup>1</sup>). Amount of lead estimated.</p>	<p>(a.) 10.0</p> <p>(a<sup>1</sup>.) 100.0</p> <p>(b.) 2.0</p> <p>(b<sup>1</sup>.) 2.0</p> <p>(c.) 4.0</p> <p>(c<sup>1</sup>.) 80.0</p>
5	<p>January 30th, 1895:—</p> <p>(a.) 10 c.c. Shipley water in test tube with lead <math>1 \times \frac{1}{4}</math>". The same water as in Experiment 9 (a), Table LXXXV.</p> <p>(b.) Same as (a), but air aspirated through the water for half an hour. The same water as in Experiment 9 (b), Table LXXXV.</p> <p>(c.) 100 c.c. of same water as in (a) evaporated to dryness in platinum crucible and residue dissolved in 100 c.c. distilled water (distillate of Shipley water). 10 c.c. in test tube with lead <math>1 \times \frac{1}{4}</math>".</p> <p>(d.) Same as (c), but residue ignited.</p>	<p>February 4th, 1895. Distinct action in (a), (b); very great action in (c), (d). Amount of lead estimated.</p>	<p>(a.) 7.5</p> <p>(b.) 7.5</p> <p>(c.) 30.0</p> <p>(d.) 40.0</p>

Experiment 1 seems to show that, up to a certain point, the addition of a hard limestone water to Shipley water tends, if anything, to increase the erosive power; but the addition of 10 or more per cent. hard water practically altogether prevents erosion. Experiment 2 and Experiment 4 (c), (c') show that heating to 100° C. acid moorland waters possessed of erosive ability does not remove their erosive power. Experiment 3 and Experiment 5 (c), (d), show that evaporating an acid erosive water to dryness, and dissolving the residue with or without previous ignition in its own distillate, not only fails to inhibit, but greatly increases the initial erosive action of the water. Experiment 4 (b), (b') seems to show that the use of coated lead need not necessarily be a complete safeguard from erosion by an acid moorland water. Experiment 5 (b) shows that complete aeration of an acid erosive moorland water does not modify appreciably its erosive power.

*Summary* (under Section I. (c)).

In a summary of the foregoing results I would specially note the following points:—

- (1.) It is important to note that acid moorland waters frequently erode *bright* lead, and that the more acid the waters are, the greater is apt to be their power to erode lead. Erosion does not seem to occur almost immediately, as in the case with distilled water, but only slowly; the lead not uncommonly acquires an imperfect coat, which later tends to fall away in patches, leaving the surface of the metal exposed to the erosive action of the water.
- (2.) Moorland waters that are neutral, or only feebly acid, usually display little or no actually appreciable erosive power; but that they are often near the possession of erosive ability may be proved by renewing the lead one or more times, and thus, by exhausting their feeble "plumbo-protective" properties, induce in them a vigorous erosive action.
- (3.) "Treatment" of the water, whether at the waterworks or in the laboratory, is seldom entirely satisfactory; because, although "treatment" frequently inhibits, or even prevents, appreciable erosion from taking place, it nevertheless leaves the water in a condition bordering on the possession of conspicuous erosive ability. Sometimes, indeed, the "treatment" seems actually to render the water more liable to erode lead. But treatment with sodium carbonate, whether in connection with a waterworks (*e.g.*, Wakefield Waterworks) or in the laboratory, if carried out in such a way as to leave traces of the salt in the water (*i.e.*, in slight excess of exact neutralisation), appears to place the treated water in a condition remote from the possession of erosive ability. The experiments seem to indicate that in practice it might be cheaper to resort to a preliminary treatment, *e.g.*, (a) lime, or (b) combined lime and sand filtration, or (c) sand and limestone filtration, so as to correct the acidity, plumbo-solvent ability, and gross erosive power. Then to supplement such preliminary "treatment" by final addition of sodium carbonate in minute amount; and thus, by endowing it with a reserve of a "plumbo-protective" substance, to place the water in a condition remote from the possession of erosive ability.

- (4.) There would seem to be this difference between erosion and plumbo-solvency : namely, that any treatment of a neutralising sort, even if imperfectly carried out, always reduces the danger from an acid moorland water as regards plumbo-solvency ; whereas, as regards erosive ability treatment of an imperfect kind may produce no appreciable inhibition of erosion, and, if laboratory experiments are to be relied on, may even in certain cases render the partially treated water more prone than before to erode lead in vigorous fashion. Treatment of any kind, be it noted, must alter the chemical composition of a water, and if accompanied by filtration, will remove the suspended matters, and therefore tend, either in a good or bad direction, to modify the kind of protective coat the treated water yields to lead. This does not of course imply any expression of doubt as to the wisdom of treating acid moorland waters. It is imperative to correct the acidity, and thereby the plumbo-solvent ability of moorland waters, since it is in this direction that manifest danger lies. In most cases there is a probability that such treatment will inhibit or prevent erosion as well ; but treatment to ensure this object should be thorough, and also should be of such a character as to place the treated water in a condition remote from the possession of erosive ability.
- (5.) Such moorland spring waters as were tested, and, but to a less extent, the moorland waters in which spring in addition, to peaty water was present, were commonly free from erosive power, and also possessed not uncommonly what may be termed a reserve of "plumbo-protective" ability.
- (6.) As regards the numerous experiments relating to erosion carried out under laboratory and artificial conditions, the greatest difficulty is experienced in drawing conclusions, as each table and often each individual experiment needs to be studied alone. Storing acid moorland waters for long periods in partially filled and unstoppered bottles and the concentration of an acid moorland water by boiling did not prevent erosion from taking place. The use of alloys of lead and tin, and "coated" lead were not altogether satisfactory as regards the prevention of erosion. Sodium carbonate, especially if present in excess of the amount required exactly to neutralise the water, proved to be most efficacious in not only preventing erosion from taking place, but placing the water in a position remote from erosive ability. Lime water appeared to be less efficacious in the latter respect. The addition of calcium bicarbonate, either in the form of artificially prepared calcium bicarbonate water, or as a natural limestone water, or by filtering water previously saturated with carbonic acid through marble, was usually satisfactory, provided a sufficient amount of the substance was present in the water. A series of experiments, in which acid moorland waters were filtered through limestone, polarite, asbestos, sand, flint, and marble, seemed to show that polarite, asbestos, sand (river sand, sandstone sand, and "HCl treated" sea sand), and flint, and, to a less degree, limestone, sea sand (untreated), and marble, were not altogether satisfactory, since either erosion was inhibited and not prevented, or the water was left in a condition not remote



from the possession of erosive ability. Nevertheless, in some of the experiments, especially those with the sea sand, the results were good. Shaking acid moorland waters with silica ( $\text{SiO}_2$ ) did not place them in a safe condition as regards ability to erode lead. Calcium and sodium phosphates had an inhibitory action; but sulphates and chlorides did not prevent erosion from taking place; nitrites and nitrates (especially ammonium nitrate) increased the power of the waters tested to erode lead. A series of experiments, in which the acid moorland waters were shaken with limestone, chalk, Iceland Spar, marble, polarite and flint, showed that polarite and flint were unreliable for the purpose of inhibiting erosion, but that the rest of the above-named substances not only inhibited erosion, but usually placed the waters in a position remote from erosive ability. Evaporating an acid moorland water to dryness and dissolving the residue (with or without ignition) in its own distillate gave a liquid possessed of greater power to erode lead than the moorland water itself.

(d.)—*Natural Waters other than Rain or Moorland Waters.*

It has already been shown that the addition of a "hard" water to distilled waters, or to acid moorland waters, removes from them ability to dissolve or to erode lead. How remote from the possession of erosive property a "hard" water may be is shown in the following table (Table LXII.) :—

TABLE LXII.

Showing the ACTION, as regards EROSION OF LEAD, of SETTLE WATER (a very hard "LIMESTONE" water) upon LEAD. Compare with Table XCIX.

No.	Description of the Experiment.	Reaction.	Remarks.
1	10 c.c. Settle water (a hard limestone water) in test tube with lead $1 \times \frac{1}{4}$ ". August 20th, 1894.	Neutral (with strong acid neutralising ability).	Oct. 4th, 1894. No action, the lead being coated with a bluish white, firmly adherent film.
2	10 c.c. Settle water (a hard limestone water) in test tube with lead $1 \times \frac{1}{4}$ ". August 20th, 1894. Aug. 21st. A fresh piece of lead put in tube in place of the old. " 22nd. A fresh piece of lead put in tube in place of the old. " 23rd. A fresh piece of lead put in tube in place of the old. " 24th. A fresh piece of lead put in tube in place of the old. " 25th. A fresh piece of lead put in tube in place of the old. " 26th. A fresh piece of lead put in tube in place of the old. " 27th. A fresh piece of lead put in tube in place of the old. " 28th. A fresh piece of lead put in tube in place of the old. " 29th. A fresh piece of lead put in tube in place of the old. " 30th. A fresh piece of lead put in tube in place of the old.	"	Oct. 4th, 1894. Still no action visible, notwithstanding the daily renewal of the lead. Each new piece of lead that was put in became coated with a bluish white, firmly adherent film.

No.	Description of the Experiment.	Reaction.	Remarks.
2— cont.	Aug. 31st. A fresh piece of lead put in tube in place of the old.		
	Sept. 1st. A fresh piece of lead put in tube in place of the old.		
	" 2nd. A fresh piece of lead put in tube in place of the old.		
	" 3rd. A fresh piece of lead put in tube in place of the old.		
	" 4th. A fresh piece of lead put in tube in place of the old.		
	" 5th. A fresh piece of lead put in tube in place of the old.		
	" 6th. A fresh piece of lead put in tube in place of the old.		
	" 7th. A fresh piece of lead put in tube in place of the old.		
	" 8th. A fresh piece of lead put in tube in place of the old.		
	" 9th. A fresh piece of lead put in tube in place of the old.		
	" 10th. A fresh piece of lead put in tube in place of the old.		
	" 11th. A fresh piece of lead put in tube in place of the old.		
	" 12th. A fresh piece of lead put in tube in place of the old.		
	" 13th. A fresh piece of lead put in tube in place of the old.		
	" 14th. A fresh piece of lead put in tube in place of the old.		
	" 15th. A fresh piece of lead put in tube in place of the old.		
	" 16th. A fresh piece of lead put in tube in place of the old.		
	" 17th. A fresh piece of lead put in tube in place of the old.		
	" 18th. A fresh piece of lead put in tube in place of the old.		
	" 19th. A fresh piece of lead put in tube in place of the old.		
	" 20th. A fresh piece of lead put in tube in place of the old.		
	" 21st. A fresh piece of lead put in tube in place of the old.		
	" 22nd. A fresh piece of lead put in tube in place of the old.		
	" 23rd. A fresh piece of lead put in tube in place of the old.		
	" 24th. A fresh piece of lead put in tube in place of the old.		
	" 25th. A fresh piece of lead put in tube in place of the old.		
	" 26th. A fresh piece of lead put in tube in place of the old.		
	" 27th. A fresh piece of lead put in tube in place of the old.		
	" 28th. A fresh piece of lead put in tube in place of the old.		
	" 29th. A fresh piece of lead put in tube in place of the old.		
	" 30th. A fresh piece of lead put in tube in place of the old.		
	Oct. 1st. A fresh piece of lead put in tube in place of the old.		
	" 2nd. A fresh piece of lead put in tube in place of the old.		
	" 3rd. A fresh piece of lead put in tube in place of the old.		

*Summary (under Section I. (d)).*

It will be seen from the foregoing table that, in the case of Settle water, the renewal of the lead once daily on 44 successive days failed to induce any erosion, each fresh piece of *bright* lead up to end of the experiment becoming and remaining coated with a bluish-white firmly adherent film. Judging from the results of the experiments described in previous tables, it would seem that to induce Settle water to erode lead it must needs be diluted at least nine times with a distilled water or an acid moorland water. Incidentally, it may be added that a water of this class, when mixed with an acid plumbo-solvent moorland water, displays a conspicuous power of neutralising the acidity and removing the plumbo-solvent ability of the moorland water mixed with it. Notwithstanding this corrective property, it is by no means inconceivable, paradoxical as it may seem, that a hard limestone water might yet by itself, if it contained carbonic acid in excess of the amount necessary to keep the lime in solution, act feebly on lead.

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## SECTION II.—PLUMBO-SOLVENCY.

In illustration of the scope and nature of the work carried out under this heading, it is of advantage to quote from Mr. Power's report\* as follows:—

"Among the earliest of his procedures, after taking charge of the laboratory at Settle, Dr. Houston set to work to test, and has since from time to time continued to test, the characters exhibited by a number of waters from different moors, in reference to the facts that had been observed at Burnmoor.

"The Burnmoor experiments, it will be remembered, indicated that ability of a water to dissolve lead is closely associated with acid reaction of the water, but with no other condition to which such water is subject. In this way a considerable number of separate waters, all of them of moorland origin, have been compared with each other and with the Burnmoor standard. And, as a result, waters of this class differed conspicuously in one other particular only, namely, as regards acidity. Those that dissolved lead were observed to possess an alkali-neutralising property; whereas those that did not dissolve lead were observed to possess an acid-neutralising property. There was no exception to this rule; whatever the direct source of the sample, whether from stagnant peat pool, from spring or gathering ground, from feeder to moorland reservoir, from service reservoir, or from town tap, this distinction was always maintained. And, further, not only was there indication of association of acidity and lead-dissolving property, but there was indication also of close relation between amount of acidity and vigour of solvent action on lead. Direct parallelism of amount of acidity and vigour of lead-dissolving power was not, however, always found in regard of the same water when tested in these respects at different times; and different waters of equal acidity did not necessarily possess equal power of dissolving lead. Each water, indeed, appeared to possess its own standard of relation of lead-dissolving property to acidity; and as the one quality varied naturally, or was artificially made to vary, so did the other, though not necessarily in direct proportion."

In illustration of the close association of lead-dissolving property and acidity under artificially contrived conditions, certain laboratory experiments by Dr. Houston may be here cited:—

"Distilled water having ability to dissolve lead and possessing also alkali-neutralising property, lost, on boiling, both properties. So, too, many moorland waters lost, when boiled, much of their lead-dissolving property and of their acidity. But certain moorland waters not only retained both properties after boiling, but manifested them in higher degree than before, to an extent indeed roughly corresponding to their concentration.

"Distilled water having ability to dissolve lead and possessing also alkali-neutralising property, lost, when aerated, both properties. So, too, many moorland waters lost when thus dealt with some of their ability to dissolve lead, and lost also some of their acidity. But other moorland waters were not influenced in either respect by this process.

"Distilled water having ability to dissolve lead and possessing also alkali-neutralising property, lost, when stored in bottles partially filled and not stoppered, much of its ability to dissolve lead, and also its property of neutralising alkali. So, too, many moorland waters similarly dealt with lost much of their ability to dissolve lead and much

\* Report of the Medical Officer, Local Government Board. Lead Poisoning by Moorland Waters. Page 841. By W. H. Power, F.R.S.

of their acidity. Other moorland waters, however, were hardly affected in either respect."

The following are details of experiments bearing on the above subjects:—

(a.) *Rain and Snow Water.*

In illustration of the qualities of rain and snow water, as regards reaction and plumbo-solvency, Table LXIII. may here be considered.

TABLE LXIII.

Showing the PLUMBO-SOLVENT ABILITY of RAIN and SNOW WATER.

[The action on lead was tested by upward filtration through 50 c.c. washed shot filtered at the uniform rate of 3 minutes per 50 c.c.]

No.	Description of Experiment.	Reaction.	Action on Lead (Results expressed as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	August 3rd, 1894. Rain-water collected from roof.	Neutral	0·0	0·0	0·0	0·0	0·0	0·0
2	August 5th, 1894. Rain-water collected from roof.	Neutral	0·0	0·0	0·0	0·0	0·0	0·0
3	August 8th, 1894. Rain-water collected from roof.	Neutral	0·0	0·0	0·0	0·0	0·0	0·0
4	January 14th, 1895. Melted snow.	Neutral	0·0	0·0	0·0	0·0	0·0	0·0
5	January 28th, 1895. Melted snow.	Neutral	0·0	0·0	0·0	0·0	0·0	0·0

*Summary (under Section II. (a)).*

It will be seen that the rain and melted snow water was neutral in reaction, and was also free from plumbo-solvent ability. It will be remembered, however, that in discussing, in a previous section of this report, the question of erosion, as regards rain-water, it was pointed out that some samples of rain-water collected on high gathering grounds in the neighbourhood of manufacturing districts might give a faint acid reaction, and be possessed not only of erosive power but also of appreciable plumbo-solvent ability. In illustration of this circumstance, but more particularly of erosive ability, a table (Table II.) was given to which attention must again be drawn. Speaking in general terms it may be said that the results showed that rain-water collected in the above situations might yield an acid reaction and dissolve lead to a slight extent. At the risk of repetition it must be pointed out that such meagre acidity and correspondingly slight plumbo-solvency is in no sense a sufficient explanation of the antecedent cause of the acidity and plumbo-solvency of moorland waters in general.

(b.) *Distilled Waters.*

Allusion has been already made to the general character of the distilled waters (referred to as X, XX, XXX) as regards reaction, power of eroding bright lead, and plumbo-solvent ability (*see* Table III.). The question of erosion has been fully considered, but so far only passing reference has been made to plumbo-solvency.

The following table (Table LXIV.) shows the reaction and plumbo-solvent ability of twenty-two separate samples of distilled water obtained by the distillation of Settle water ("hard" limestone water).

TABLE LXIV.

Showing the PLUMBO-SOLVENT ABILITY of DISTILLED WATER  
(X, XX, XXX).

[The action on lead was tested by upward filtration through 50 c.c.  
washed shot.]

Experiment.	Description of the Sample of Water used for Distillation purposes.	Reaction with Lead.	Action on Lead (Results stated as Parts per 100,000).					Average.	Average Duration of Experiment in Minutes per 50 c.c.
			1st. 50 c.c.	2nd. 50 c.c.	3rd. 50 c.c.	4th. 50 c.c.	5th. 50 c.c.		
I.									
a.	Settle water, distillate X	Acid -	0.4	0.6	0.8	0.8	0.8	0.68	7
b.	" " XX	Slightly acid.	0.2	0.4	0.4	0.4	0.4	0.36	7
II.									
a.	Settle water, distillate X	Acid -	0.4	1.0	0.8	0.7	0.6	0.70	5
b.	" " XX	" -	0.2	0.9	0.7	0.8	0.8	0.68	5
c.	" " XXX	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	7
III.									
a.	Settle water, distillate X	Acid -	0.2	0.7	0.7	0.8	0.6	0.60	5
b.	" " XX	" -	0.1	0.2	0.6	0.6	0.6	0.42	5
c.	" " XXX	Faintly acid.	0.0	0.0	0.0	0.0	0.0	0.00	5
IV.									
a.	Settle water, distillate X	Acid -	0.2	0.8	0.9	0.8	0.8	0.70	6
b.	" " XX	Slightly acid.	0.0	0.2	0.4	0.4	0.4	0.28	6
c.	" " XXX	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	6
V.									
a.	Settle water, distillate X	Acid -	0.9	1.4	1.4	1.4	1.2	1.26	5
b.	" " XX	" -	0.0	0.0	0.6	0.8	0.6	0.40	8
c.	" " XXX	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	7
VI.									
a.	Settle water, distillate X	Acid -	0.4	1.0	1.0	0.8	0.8	0.80	6
b.	" " XX	" -	0.0	0.2	0.6	0.5	0.5	0.36	5
c.	" " XXX	Very faintly acid.	0.0	0.0	0.0	0.0	0.0	0.00	5
VII.									
a.	Settle water, distillate X	Acid -	0.2	0.8	1.0	0.8	0.8	0.72	5
b.	" " XX	Slightly acid.	0.0	0.2	0.4	0.3	0.3	0.24	5
VIII.									
a.	Bentham water, distillate X	Acid -	0.0	0.2	0.4	0.4	0.4	0.28	4
IX.									
a.	Bentham water, distillate X	" -	0.0	0.0	0.2	0.4	0.4	0.20	4
X.									
a.	Settle water, distillate X	Acid -	0.4	0.7	0.7	0.8	0.8	0.68	3
b.	" " XX	Slightly Acid.	0.1	0.1	0.2	0.4	0.4	0.24	3
c.	" " XXX	Trace -	0.1	0.0	0.0	0.0	0.1	0.04	3
XI.									
a.	Settle water, distillate X	Acid -	0.4	0.5	0.6	0.7	0.8	0.60	3
b.	" " XX	Slightly Acid.	0.1	0.1	0.2	0.2	0.2	0.16	3
c.	" " XXX	Trace -	0.0	0.0	0.0	0.05	0.1	0.03	3

TABLE LXIV—continued.

Experiment.	Description of the Sample of Water used for Distillation purposes.	Reaction with Lacmoid.	Action on Lead (Results stated as Parts per 100,000).						Average Duration of Experiment in Minutes per 50 c.c.
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
XII.									
a.	Settle water, distillate X	Acid -	0.2	0.6	0.8	0.8	0.9	0.66	3
b.	" " XX	Slightly acid.	0.0	0.1	0.1	0.1	0.2	0.10	3
c.	" " XXX	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	3
XIII.									
a.	Settle water, distillate X	Acid -	0.3	0.5	0.6	0.6	0.8	0.56	3
b.	" " XX	" -	0.0	0.1	0.3	0.4	0.3	0.23	3
c.	" " XXX	Trace -	0.0	0.0	0.0	0.1	0.1	0.04	3
XIV.									
a.	Settle water, distillate X	Acid -	0.5	0.7	0.7	0.8	0.8	0.70	3
b.	" " XX	Slightly acid.	0.1	0.2	0.2	0.2	0.4	0.22	3
c.	" " XXX	Trace -	0.0	0.0	0.0	0.1	0.1	0.04	3
XV.									
a.	Settle water, distillate X	Acid -	0.7	1.0	1.0	1.0	1.0	0.94	3
b.	" " XX	" -	0.2	0.5	0.5	0.6	0.7	0.50	3
c.	" " XXX	Slightly acid.	0.1	0.1	0.2	0.2	0.2	0.16	3
XVI.									
a.	Settle water, distillate X	Acid -	0.6	1.2	1.2	1.2	1.2	1.08	3
b.	" " XX	" -	0.0	0.4	0.6	0.7	0.6	0.46	3
c.	" " XXX	Trace -	0.0	0.0	0.2	0.2	0.2	0.12	3
XVII.									
a.	Settle water, distillate X	Acid -	0.3	0.7	0.8	1.0	0.9	0.74	3
b.	" " XXX	Trace -	0.0	0.0	0.1	0.2	0.2	0.10	3
XVIII.									
a.	Settle water, distillate X	Acid -	0.8	1.2	1.2	1.2	1.3	1.14	3
b.	" " XXX	Slightly acid.	0.0	0.1	0.1	0.2	0.2	0.12	3
XIX.									
a.	Settle water, distillate X	Acid -	0.6	0.8	0.8	0.8	1.0	0.80	3
b.	" " XX	Slightly acid.	0.1	0.4	0.4	0.6	0.5	0.40	3
c.	" " XXX	Trace -	0.0	0.0	0.0	0.1	0.1	0.04	3
XX.									
a.	Settle water, distillate X	Acid -	0.6	1.0	1.2	1.0	1.1	0.98	3
b.	" " XXX	Trace -	0.0	0.0	0.1	0.2	0.2	0.10	3
XXI.									
a.	Settle water, distillate X	Acid -	0.4	0.6	0.8	0.6	0.8	0.60	3
b.	" " XX	" -	0.1	0.2	0.2	0.3	0.4	0.24	3
c.	" " XXX	Slightly acid.	0.0	0.1	0.1	0.2	0.2	0.12	3
XXII.									
a.	Settle water, distillate X	Acid -	0.6	0.8	1.0	1.0	1.0	0.88	3
b.	" " XX	" -	0.4	0.6	0.6	0.6	0.6	0.56	3
c.	" " XXX	Trace -	0.0	0.0	0.05	0.1	0.1	0.05	3

It will be noted that X distilled water was always distinctly acid, and possessed of decided plumbo-solvent ability. XXX distilled water, on the other hand, was neutral, or only contained traces of acid, and either had no plumbo-solvent ability, or dissolved only traces of lead. XX distilled water occupied an intermediate position, both as regards acidity and degree of plumbo-solvency.

It will be remembered that, in connection with the consideration of the question of erosion, it was shown that a non-erosive X distilled water could by a variety of methods be converted into what corresponded to an erosive XXX distilled water. Similarly, it will now be shown that X distilled water can be changed from an acid plumbo-solvent water to a neutral water free from plumbo-solvency, and, therefore, practically into an XXX distilled water.

TABLE LXV.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of keeping X DISTILLED WATER in Partially Filled and Unstoppered Bottles.

[The action on lead was tested by upward filtration through 50 c.c. washed shot, at a uniform rate of 3 minutes per 50 c.c.]

Sample.	Description of Experiment.	Reaction.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Distilled water X	Acid -	0.2	0.7	0.7	0.8	0.6	0.60
	Distilled water X, after 30 days.	Paint acidity.	0.0	0.0	0.1	0.2	0.2	0.10
	Distilled water X, after 120 days.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
2	Distilled water X, May 31st, 1894.	Acid -	0.3	0.7	0.8	1.0	0.9	0.74
	Distilled water X, after 8 days.	Slightly acid.	0.1	0.3	0.4	0.4	0.6	0.36
3	Distilled water X, June 1st, 1894.	Acid -	0.6	1.2	1.2	1.2	1.3	1.54
	Distilled water X, after 7 days.	Slightly acid.	0.0	0.0	0.1	0.2	0.2	0.10
4	Distilled water X, Dec. 14th, 1894.	Acid -	0.3	1.0	1.2	1.4	1.6	1.10
	Distilled water X, after 24 days.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

The above table shows that storing, for some time, an X distilled water in partially filled and unstoppered bottles has the effect of changing it from an acid plumbo-solvent water into a practically neutral and non-plumbo-solvent water.



TABLE LXVI.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of boiling  
X DISTILLED WATER.

Experiment.	Description of the Sample of Water.	Reaction.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed lead shot.						Average Duration of Experiment in Mins. per 50 c.c.
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	Settle water, distillate X -	Acid	0.4	1.0	1.0	0.8	0.8	0.80	6
	The same water after boiling.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	9
2	Settle water, distillate X -	Acid	0.2	0.8	1.0	0.8	0.8	0.72	5
	The same water after boiling.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	5
3	Bentham water, distillate X.	Acid	0.0	0.2	0.4	0.4	0.4	0.28	4
	The same water after boiling.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	4
4	Settle water, distillate X -	Acid	0.6	1.2	1.2	1.2	1.2	1.08	3
	The same water after boiling.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	3

It will be noted that a similar effect is produced by boiling X distilled water.

In contrast to the above, Table LXVII. shows that if X distilled be stored in completely filled and stoppered bottles for some time, it retains its acidity and power of dissolving lead.

TABLE LXVII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of keeping  
X DISTILLED WATER in Completely Filled and Stoppered Bottles.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot, at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Reaction.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Settle water, distillate X, February 8th, 1895.	Acid	0.3	0.4	0.6	0.	0.	0.50
	Settle water, distillate X, after 20 days.	"	0.3	0.4	0.4	0.4	0.4	0.38
2	Settle water, distillate X, February 9th, 1895.	"	0.2	0.4	0.4	0.5	0.5	0.40
	Settle water, distillate X, after 24 days.	"	0.2	0.4	0.5	0.5	0.5	0.42
3	Settle water, distillate X, February 14th, 1895.	"	0.6	0.9	0.9	0.9	0.9	0.84
	Settle water, distillate X, after 25 days.	"	0.6	0.9	0.9	0.9	0.9	0.84
4	Settle water, distillate X, February 16th, 1895.	"	0.6	0.7	0.8	0.8	0.8	0.74
	Settle water, distillate X, after 27 days.	"	0.4	0.6	0.8	0.8	0.8	0.68

The following table (Table LXVIII.) shows the effect, as regards plumbo-solvency, of placing distilled water under various conditions:—

TABLE LXVIII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of placing DISTILLED WATER under various Conditions.

Experiment.	Description of Experiment.	Re-action.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed lead shot.						Average duration of Experiment in Mins. per 50 c.c.
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	Distilled water, boiled, cooled rapidly, and tested.	Neutral	0·0	0·0	0·0	0·0	0·0	0·00	6
2	Distilled water, boiled, cooled, fully aerated.	Neutral	0·0	0·0	0·0	0·0	0·0	0·00	6
3	Distilled water, boiled, cooled, then hydrogen gas passed through.	Neutral	0·0	0·0	0·0	0·0	0·0	0·00	6
4	Distilled water, boiled, cooled, then carbonic acid gas passed through.	Acid	2·8	2·8	2·8	2·8	2·8	2·80	6
5	Distilled water, boiled, cooled, carbonic acid gas passed through, then neutralised.	Neutral	0·0	0·0	0·0	0·0	0·0	0·00	5
6	Distilled water, boiled, cooled, carbonic acid gas passed through and then hydrogen gas.	Faintly acid.	0·0	0·0	0·1	0·2	0·2	0·10	4
	Distilled water, boiled, cooled, carbonic acid gas passed through and then boiled.	Neutral	0·0	0·0	0·0	0·0	0·0	0·00	4
8	Settle water, distillate X	Acid	0·4	0·6	0·6	0·6	0·8	0·60	3
	The same water after being fully aerated.	Neutral	0·0	0·0	0·0	0·0	0·0	0·00	3
9	Settle water, distillate X	Acid	0·4	0·6	0·7	0·6	0·6	0·58	3
	The same water after washed air passed through for half an hour	Neutral	0·0	0·0	0·0	0·0	0·0	0·00	3

Experiments 1, 2, 3, 5, and 7 show that if distilled water be (a) boiled, cooled rapidly, and then tested; (b) boiled, cooled and fully aerated; (c) boiled, cooled, then hydrogen gas passed through it; (d) boiled, cooled, carbonic acid gas passed through it and then neutralised; (e) boiled, cooled, carbonic gas passed through it and then boiled, the water in each case gives a neutral reaction and does not dissolve lead to any appreciable extent. Practically speaking, the same holds good as regards Experiment 6, where the water after being boiled and cooled had carbonic acid gas passed through it and then hydrogen gas; but here the water remained faintly acid and acted appreciably on lead. In Experiment 4, distilled water was boiled, cooled, and then carbonic acid gas passed through it. The water was distinctly acid and dissolved lead to a decided extent. In Experiments 8 and 9, X distilled water, after aeration, lost its acidity and plumbo-solvent ability.

The following table (Table LIX.) shows the effect, as regards plumbo-solvency, of the neutralisation of distilled water :—

TABLE LIX.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the NEUTRALISATION OF DISTILLED WATER.

Experiment.	Description of the Sample of Water.	Reaction.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed lead shot.						Average Duration of Experiment in Mins. per 50 c.c.
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	Settle water, distillate X -	Acid	0.2	0.8	0.9	0.8	0.8	0.70	6
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	6
2	Settle water, distillate X -	Acid	0.4	1.0	1.0	0.8	0.8	0.80	6
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	7
3	Settle water, distillate XX	Acid	0.0	0.2	0.6	0.5	0.5	0.36	5
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	5
4	Settle water, distillate X -	Acid	0.2	0.8	1.0	0.8	0.8	0.72	5
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	5
5	Bentham water, distillate X	Acid	0.0	0.2	0.4	0.4	0.4	0.28	4
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	4
6	Settle water, distillate X -	Acid	0.3	0.7	0.8	1.0	0.9	0.74	3
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	3
7	Settle water, distillate X -	Acid	0.8	1.2	1.2	1.2	1.3	1.14	3
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	3
8	Settle water, distillate X -	Acid	0.4	0.6	0.6	0.6	0.8	0.60	5
	The same water after neutralising.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00	3

The above table shows that X distilled water, after neutralisation, loses its acidity and power of dissolving lead.

In a number of the tables dealing with the plumbo-solvency under different conditions of moorland waters, experiments with distilled water are also included, but these need not be considered here.

#### Summary (under Section II. (b)).

In a summary of the foregoing all that need be said is that distilled water which gives a neutral reaction has little or no plumbo-solvent ability. Acid distilled water, however, has a decided solvent

action on lead. X distilled water, which is acid and dissolves lead, loses both these properties if placed under certain varied conditions, *e.g.*, boiling, aeration, neutralisation, storing in partially filled and unstoppered bottles, &c.

(c.) *Moorland Waters.*

The correlation of acidity and lead-dissolving property and the close relation between amount of acidity and vigour of solvent action on lead are matters considered in detail in Volume I. This report deals incidentally with the same subject, but it also treats of the effect, as regards plumbo-solvency, of the additions to moorland waters of various substances and of placing moorland waters under a number of different conditions.

The source and nature of the moorland waters used for the above experiments has been fully explained in Volume I. No reasons need therefore be given for selecting them, for experimental purposes, as typical natural plumbo-solvent waters. But, as so many of the experiments deal with Shipley, Mossley, and, in a few instances, with Settle Peat Pool water (the latter not being dealt with in Volume I.), there would seem to be an advantage in considering here the sustained laboratory experiments as to the acidity and plumbo-solvency and chemical composition of the above waters.

It is of advantage also to include the results of the examination as regards acidity and plumbo-solvent ability of the "inlet" water to and the "outlet" water from Sheephouse Reservoir (Bacup Corporation Waterworks), as the observations cover a considerable period of time and clearly illustrates the close association of acidity with plumbo-solvency.

It is convenient, in the first place, to consider the result of the examination of Shipley (Eldwick) Reservoir\* water, an example of a moorland water consistently and to a remarkable degree possessed of the properties of acidity and plumbo-solvency.

The following table (Table LXX.), on pages 128, 129, shows the results of the chemical examination of the water obtained from Eldwick Reservoir (Shipley Water Supply).

It will be seen from the Table LXX. that there is nothing peculiar in the chemical composition of Shipley (Eldwick) water. The oxygen absorbed from permanganates and the albumenoid ammonia figures are doubtless rather high, but this is only what might be anticipated in the case of a moorland water. Yet this water uniformly dissolved lead to a remarkable extent, and the only factor in the chemical analysis of the water to be associated with this property was its extreme acidity. It would be difficult to find a water yielding uniformly, as regards acidity and plumbo-solvency, such high figures. These results are best appreciated by reference to the table on pages 130-134 (Table LXXI.), in which all the results as regards acidity and plumbo-solvency are placed side by side.

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\* For a description of Shipley (Eldwick) Waterworks, see Volume I.

TABLE

Showing the RECORD of the CHEMICAL EXAMINATION of the  
Results stated in

Date of Examination.	Appearance.			Reaction with Lactmoid.	Residue on Evaporation.			Ammonia.		Oxidised Nitrogen.		Oxygen required for Organic Matter at 100° C.
	Colour.	Turbidity.	Residue.		Total.	Loss on Ignition.	Fixed.	Free.	Albumenoid.	Total.	As Nitrates.	
1894.												
Feb. 27	Yellow	Dim	Slight	Acid	8	4	4	'002	'016	'036	Trace	0'48
Mar. 5	"	"	"	"	8	2	6	'006	'011	'333	Nil	0'37
" 13	"	"	"	"	10	5	5	'006	'026	'039	Trace	0'66
" 20	"	"	"	"	9	5	4	'003	'014	'023	Nil	0'30
" 27	"	"	"	"	8	4	4	'002	'024	'010	"	0'38
April 3	"	"	"	"	9	4	5	'010	'005	'016	Trace	0'35
" 10	"	"	Con- siderable.	"	7	3	4	'007	'009	'013	"	0'36
" 17	"	"	Slight	"	9	4	5	'004	'014	—	"	0'60
May 29	"	"	"	"	8	3	5	'013	'011	'016	Nil	0'18
June 4	"	"	"	"	8	4	4	'005	'016	'016	"	0'56
" 11	"	"	"	"	8	5	3	'004	'012	'046	Trace	0'68
" 18	"	"	"	"	9	4	5	'009	'017	'023	Nil	0'35
" 25	"	"	"	"	11	6	5	'008	'016	'049	"	0'56
July 3	"	"	"	"	7	3	4	'004	'022	'020	"	0'08
" 9	"	"	"	"	9	4	5	'003	'020	'019	"	—
" 16	"	"	"	"	8	3	5	'012	'012	'039	Trace	0'07
" 23	"	"	"	"	9	5	4	'014	'012	'036	Nil	0'16
" 30	"	"	"	"	—	—	—	—	—	—	—	—
Aug. 6	"	"	"	"	6	—	—	'016	'006	—	Nil	0'10
" 13	"	"	"	"	—	—	—	—	—	—	—	—
" 21	"	"	"	"	8	—	—	'007	'016	—	Nil	0'56
" 27	"	"	"	"	8	—	—	'002	'002	—	—	0'31
Sept. 3	"	"	"	"	6	—	—	'016	'014	—	—	0'11

\* The chemical examination of this water, so far as acidity and plumbic-solvency are

LXX.

WATER obtained from ELDWICK RESERVOIR (Shipley Water Supply).

Parts per 100,000.

Chlorine.	Hardness. Total.	Dissolved Oxygen.	Iron.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Plumbo-solvency, as shown by amount of Lead taken up in Samples. The action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.*						Weekly Rainfall (in Inches) on Shipley Gathering Ground.	
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.		
1.3	4.1	1.29	Present	1.00	0.8	2.0	2.4	2.8	3.2	2.24	1894. Feb. 24	Ins. - 0.44
1.3	4.3	1.24	"	1.08	0.8	2.0	2.2	2.4	2.8	2.04	Mar. 3	- 0.73
1.7	5.0	1.22	"	1.15	1.0	2.6	2.8	3.2	3.6	2.64	" 10	- 0.92
1.3	4.2	1.16	"	0.90	0.6	1.2	1.6	1.8	2.0	1.44	" 17	- 0.95
1.3	5.0	1.15	"	1.00	0.8	2.2	2.8	3.2	3.2	2.44	" 24 " 31	- 0.00 - 0.00
1.4	4.3	1.15	"	1.08	2.0	2.5	3.0	3.0	3.0	2.70	April 7	- 0.80
1.6	5.0	1.13	"	1.08	1.0	2.5	3.0	3.0	3.0	2.50	" 14	- 0.84
1.7	6.6	1.18	"	1.20	2.0	4.0	3.0	3.0	3.0	3.00	" 21 " 28	- 0.76 - 0.49
1.7	5.3	1.30	"	1.20	1.0	2.0	2.0	2.0	3.0	2.00	May 5 " 12 " 19 " 26	- 0.39 - 0.74 - 0.43 - 0.02
1.6	6.7	1.22	"	1.30	3.0	4.0	4.0	4.0	5.0	4.00	June 2	0.53
1.2	4.9	1.17	"	1.20	1.5	3.0	3.0	3.0	4.0	2.90	" 9	- 2.17
1.4	4.6	1.06	"	1.08	1.5	3.0	3.5	4.0	4.0	3.20	" 16	- 0.48
1.3	6.2	0.962	"	1.08	2.0	3.0	3.0	5.5	3.0	2.90	" 23 " 30	- 0.17 - 0.18
1.3	5.3	0.93	"	1.08	2.0	3.0	3.0	3.0	3.0	2.80	July 7	- 0.25
1.3	5.3	1.04	"	1.14	1.0	2.0	2.5	3.0	3.0	2.30	" 14	- 3.38
1.3	4.5	1.05	"	1.20	1.5	2.5	3.0	3.0	3.0	2.60	" 21	- 0.24
1.4	4.9	1.04	"	1.02	1.0	2.0	3.0	3.5	4.0	2.70	" 23	- 2.08
—	—	—	"	1.08	0.5	2.0	2.0	2.0	2.0	1.70		
1.4	4.9	—	"	1.08	0.5	2.0	2.5	3.0	2.5	2.10	Aug. 4	- 0.87
—	—	—	"	0.96	1.0	2.5	2.0	3.0	2.6	2.10	" 11	- 3.28
1.4	5.6	—	"	1.20	2.0	4.0	4.0	5.0	5.0	4.00	" 18	- 0.64
1.4	5.4	—	"	1.08	1.0	3.0	3.0	3.0	3.0	2.60	" 25	- 0.56
1.4	5.3	—	"	0.90	1.0	3.0	3.0	4.0	3.0	2.80	Sept. 1 " 8	- 0.79 - 0.35

concerned, was carried out beyond Sept. 3, 1894. The results are given in Table LXXI.

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TABLE LXXI.

Showing the RESULTS of the CHEMICAL EXAMINATION of the WATER obtained from ELDWICK RESERVOIR (Shipley Water Supply) as regards ACIDITY and PLUMBO-SOLVENCY, &c.

Eldwick Reservoir Water.											
Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lecmoid.	Acidity in Terms of c.c. "Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water. Phenol- phthalein used as indicator.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Weekly Rainfall on the Gathering Ground.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	1894. Feb. 27	4.1	Acid	1.00	0.8	2.0	2.4	2.8	3.2	2.24	February 1894. 3rd, 10th, 17th, 24th. Inches. 0.25, 0.74, 1.50, 0.41.
2	Mar. 5	4.5	"	1.08	0.8	2.0	2.2	2.4	2.8	2.04	March 1894. 3rd, 10th, 17th, 21th, 31st. Inches. 0.73, 0.92, 0.95, 0.00, 0.00.
3	" 13	5.0	"	1.15	1.0	2.6	2.8	3.2	3.6	2.64	
4	" 20	4.2	"	0.90	0.6	1.2	1.6	1.8	2.0	1.44	
5	" 27	5.0	"	1.00	0.8	2.2	2.8	3.2	3.2	2.44	
6	April 3	4.3	"	1.08	2.0	2.5	3.0	3.0	3.0	2.70	April 1894. 7th, 14th, 21st, 28th. Inches. 0.80, 0.84, 0.76, 0.49.
7	" 10	5.0	"	1.08	1.0	2.5	3.0	3.0	3.0	2.50	
8	" 17	6.6	"	1.20	2.0	4.0	3.0	3.0	3.0	3.00	
9	May 29	5.3	"	1.20	1.0	2.0	2.0	2.0	3.0	2.00	May 1894. 5th, 12th, 19th, 26th. Inches. 0.39, 0.74, 0.43, 0.02.
10	June 4	6.7	"	1.30	3.0	4.0	4.0	4.0	5.0	4.00	June 1894. 2nd, 9th, 16th, 23rd, 30th. Inches. 0.53, 2.17, 0.48, 0.17, 0.16.
11	" 11	4.9	"	1.20	1.5	3.0	3.0	3.0	4.0	2.90	
12	" 18	4.6	"	1.08	1.5	3.0	3.5	4.0	4.0	3.20	
13	" 25	6.2	"	1.08	2.0	3.0	3.0	3.5	3.0	2.90	
14	July 3	5.3	"	1.08	2.0	3.0	3.0	3.0	3.0	2.80	July 1894. 7th, 14th, 21st, 28th. Inches. 0.25, 0.36, 0.34, 2.08.
15	" 9	5.5	"	1.14	1.0	2.0	2.5	3.0	3.0	2.30	
16	" 16	4.5	"	1.26	1.5	2.5	3.0	3.0	3.0	2.00	
17	" 23	4.0	"	1.02	1.0	2.0	3.0	3.5	4.0	2.70	
18	" 30	—	"	1.08	0.5	2.0	2.0	2.0	2.0	1.70	
19	Aug. 6	4.9	"	1.08	0.5	2.0	2.5	3.0	2.5	2.10	August 1894. 4th, 11th, 18th, 25th. Inches. 0.87, 0.23, 0.64, 0.59.
20	" 13	—	"	0.96	1.0	2.5	2.0	3.0	2.0	2.10	
21	" 21	5.6	"	1.20	2.0	4.0	4.0	5.0	5.0	4.00	
22	" 27	5.4	"	1.08	1.0	3.0	3.0	3.0	3.0	2.60	
23	Sept. 3	5.3	"	0.90	1.0	3.0	3.0	4.0	3.0	2.80	September 1894. 1st, 8th, 15th, 22nd, 29th. Inches. 0.79, 0.55, 0.01, 0.33, 0.01.
24	" 10	4.2	"	0.96	1.0	2.0	2.0	2.5	2.5	2.00	
25	" 17	4.9	"	0.96	1.0	2.0	3.0	3.0	3.0	2.40	
26	" 25	5.3	"	0.90	1.0	2.0	2.0	2.5	3.0	2.10	

TABLE LXXI.—continued.

Eldwick Reservoir Water.											Weekly Rainfall on the Gathering Ground.
Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in terms of c.c. of $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of Water. Phenol- phthalein used as Indicator.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1894.											
15	Oct. 1	5.2	Acid	0.90	1.0	3.0	3.0	3.0	4.0	2.80	October 1894. 6th, 13th, 20th, 27th. Inches. 0.16, 0.54, 0.34, 3.49.
14	" 8	5.3	"	1.08	2.0	3.0	3.5	3.5	4.0	3.20	
13	" 15	4.9	"	0.90	1.0	3.0	3.0	3.0	4.0	2.80	
31	" 23	5.3	"	1.20	3.0	4.0	4.0	4.0	4.0	3.80	
31	" 26	5.3	"	0.96	1.5	4.5	4.0	3.5	4.0	3.70	
42	" 30	5.6	"	1.00	1.0	3.0	3.0	4.0	4.0	3.00	
33	Nov. 5	5.6	"	1.02	2.0	2.5	3.5	3.0	3.0	2.80	November 1894. 3rd, 10th, 17th, 24th. Inches. 0.53, 0.41, 0.88, 0.28.
34	" 13	5.9	"	1.02	2.0	3.0	3.5	4.0	4.0	3.30	
35	" 19	6.2	"	1.08	1.5	3.0	2.5	3.0	3.0	2.60	
36	" 26	5.6	"	0.90	0.5	1.5	2.0	2.5	2.0	1.70	
37	Dec. 3	5.4	"	0.84	1.5	2.0	2.5	2.5	2.5	2.20	December 1894. 1st, 8th, 15th, 22nd, 29th. Inches. 0.00, 0.09, 0.26, 1.36, 0.24.
38	" 10	6.0	"	0.96	1.0	2.5	2.5	2.5	2.5	2.20	
39	" 17	5.5	"	1.20	2.5	3.0	3.5	3.5	4.0	3.30	
40	" 24	5.2	"	0.96	1.5	2.0	3.0	3.5	3.5	2.70	
41	" 31	5.2	"	0.96	1.5	3.0	3.0	3.0	3.0	2.70	
1895.											
42	Jan. 8	4.9	"	0.90	1.5	3.0	3.0	3.0	3.0	2.70	January 1895. 5th, 12th, 19th, 26th. Inches. 0.58, 0.46, 1.62, 1.14.
43	" 15	4.9	"	0.84	1.5	2.0	2.5	3.0	3.0	2.40	
44	" 21	4.9	"	1.02	1.0	2.5	2.5	3.0	3.0	2.40	
45	" 29	5.4	"	0.96	1.0	2.5	2.5	2.5	2.5	2.20	
46	Feb. 5	5.5	"	0.96	1.0	2.5	3.0	3.0	3.0	2.50	February 1895. 2nd, 9th, 16th, 23rd. Inches. 0.61, 0.32, 0.01, 0.00.
47	" 12	4.9	"	0.78	1.0	1.5	1.5	2.0	2.0	1.60	
48	" 17	4.2	"	0.54	0.5	1.0	1.0	1.5	1.5	1.10	
49	" 26	4.9	"	0.96	1.5	2.0	2.0	2.0	2.0	1.90	
50	Mar. 5	4.9	"	0.84	2.0	2.5	2.5	3.0	3.0	2.60	March 1895. 2nd, 9th, 16th, 23rd, 30th. Inches. 0.44, 0.50, 0.81, 0.38, 1.06.
51	" 12	4.9	"	0.90	1.5	2.0	2.0	2.0	2.0	1.90	
52	" 19	5.2	"	0.90	1.5	1.5	2.0	2.0	2.0	1.80	
53	" 26	5.0	"	0.84	1.5	2.0	2.0	2.0	2.5	2.00	
54	April 2	5.7	"	0.90	2.0	2.5	3.0	3.0	3.0	2.70	April 1895. 6th, 13th, 20th, 27th. Inches. 0.85, 0.29, 0.25, 2.13.
55	" 9	5.3	"	0.84	1.5	2.0	2.0	2.5	2.5	2.10	
56	" 16	5.3	"	0.72	0.5	1.0	1.5	1.5	1.5	1.20	

\* In experiments 46-57 inclusive, the amount of iron present in the various samples of water was estimated. The amount was found to be as nearly as possible always the same, viz., 1 part in 100,000 parts.

† In experiments 51-58 inclusive, the amount of acidity was determined with methyl orange as well as with phenolphthalein as indicator. The results, taken in order, are as follows:—0.30, 0.30, 0.24, 0.30, 0.24, 0.18, 0.18, 0.50, 0.18, 0.18, 0.18, 0.24, 0.18, 0.18, 0.18. The figures represent c.c. of  $\frac{1}{10}$  N<sub>2</sub>CO<sub>3</sub> required to neutralise 100 c.c. of the water.



TABLE LXXI.—continued.

Eldwick Reservoir Water.											
Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in terms of c.c. 10% Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water. Phenolphthalein used as Indicator.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Weekly Rainfall on the Gathering Ground.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
57	1895. April 23	5.6	Acid	0.78	1.0	1.5	2.0	2.0	2.0	1.70	
58	" 30	6.9	"	0.96	1.5	2.5	2.5	2.5	2.0	2.20	
59	May 7	6.0	"	0.78	1.0	1.0	1.5	1.5	2.0	1.40	May 1895. 4th, 11th, 18th, 25th. Inches.
60	" 14	5.7	"	0.78	1.0	2.0	2.0	2.0	2.0	1.80	0.20, 0.00, 0.06, 0.23.
61	" 21	6.0	"	0.72	1.0	1.5	2.0	2.0	2.0	1.70	
62	" 28	6.4	"	0.78	1.5	2.5	3.0	2.5	2.5	2.40	
63	June 4	7.3	"	0.96	2.0	2.5	2.5	2.5	2.5	2.40	June 1895. 1st, 8th, 15th, 22nd, 29th. Inches.
64	" 11	6.4	"	0.78	1.0	1.0	1.5	1.5	1.5	1.30	0.40, 1.35, 0.11, 0.00, 0.81.
65	" 18	6.3	"	0.72	1.0	2.0	2.0	2.0	2.0	1.80	
66	" 25	6.7	"	0.72	1.5	2.0	2.0	2.0	2.0	1.90	
67	July 2	6.7	"	0.72	1.0	1.0	1.5	2.0	2.0	1.50	July 1895. 6th, 13th, 20th, 27th. Inches.
68	" 9	6.4	"	0.78	1.5	1.5	1.5	2.0	2.0	1.70	1.24, 0.56, 0.94, 3.14.
69	" 16	6.2	"	0.72	1.0	1.5	1.5	2.0	2.0	1.60	
70	" 23	8.1	"	1.08	2.0	3.0	2.5	3.0	2.5	2.60	
71	" 30	7.4	"	1.02	2.5	3.5	3.5	3.0	3.0	3.10	
72	Aug. 6	7.0	"	1.10	1.0	2.0	2.5	2.5	3.0	2.20	August 1895. 3rd, 10th, 17th, 24th, 31st. Inches.
73	" 13	7.0	"	0.96	1.5	2.0	2.5	2.5	2.5	2.20	0.37, 0.32, 1.32, 0.59, 0.97.
74	" 20	7.0	"	0.90	2.5	3.0	2.5	3.0	3.0	2.80	
75	" 27	7.4	"	0.90	1.5	2.0	2.5	2.5	3.0	2.30	
76	Sept. 3	7.3	"	0.90	1.0	1.5	1.5	1.5	2.0	1.50	September 1895. 7th, 14th, 21st, 28th. Inches.
77	" 10	7.1	"	0.90	0.5	1.0	1.5	2.0	2.0	1.40	1.81, 0.26, 0.00, 0.06.
78	" 17	7.1	"	0.90	1.0	1.5	2.0	1.5	2.0	1.60	
79	" 24	7.0	"	0.90	1.0	1.0	1.5	1.5	1.5	1.30	
80	Oct. 1	7.6	"	0.84	1.0	1.5	1.5	1.5	1.5	1.40	October 1895. 5th, 12th, 19th, 26th. Inches.
81	" 8	7.7	"	1.02	1.5	1.5	1.5	1.5	2.0	1.60	1.30, 0.63, 0.54, 0.58.
82	" 15	7.3	"	0.84	1.0	1.5	1.0	1.5	1.5	1.30	
83	" 22	6.8	"	0.84	1.0	1.0	1.5	1.5	1.5	1.30	
84	" 29	6.9	"	0.84	0.5	1.5	1.0	1.5	1.5	1.20	
85	Nov. 5	7.1	"	0.84	1.0	1.0	1.0	1.5	1.5	1.20	November 1895. 2nd, 9th, 16th, 23rd, 30th. Inches.
86	" 12	—	"	1.02	1.0	1.5	1.5	2.0	2.5	1.70	0.14, 0.59, 2.84, 1.72, 0.59.
87	" 18	—	"	0.84	1.0	1.5	1.5	1.5	1.5	1.40	
88	" 26	—	"	0.90	1.0	1.5	1.5	1.5	2.0	1.50	
89	Dec. 3	—	"	0.84	1.0	1.0	1.0	1.0	1.5	1.10	December 1895. 7th, 14th, 21st, 28th. Inches.
90	" 10	—	"	0.90	1.0	1.0	1.5	1.5	1.5	1.30	1.58, 0.74, 0.34, 0.12.

TABLE LXXI.—*continued.*

## Eldwick Reservoir Water.

Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in terms of c.c. of $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of Water. Phenol- phthalein used as Indicator.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Weekly Rainfall on the Gathering Ground.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1895.											
91	Dec. 18	—	Acid	0.90	0.5	1.0	1.0	1.5	2.0	1.20	
92	" 24	—	"	0.84	0.5	1.0	1.0	1.0	1.0	0.90	
93	" 31	—	"	0.84	1.2	1.6	1.6	1.6	1.2	1.44	
1896.											
94	Jan. 7	—	"	0.84	0.5	0.5	1.0	1.0	1.0	0.80	January 1896. 4th, 11th, 18th, 25th. Inches.
95	" 13	—	"	0.90	1.0	1.5	1.5	1.5	2.0	1.50	0.88, 0.00, 0.67, 0.15.
96	" 21	—	"	0.96	1.5	1.5	2.0	2.0	2.0	1.80	
97	" 28	—	"	0.96	1.5	1.5	2.0	2.0	2.0	1.80	
98	Feb. 4	—	"	0.84	0.5	1.0	1.0	1.0	1.0	0.90	February 1896. 1st, 8th, 15th, 22nd, 29th. Inches.
99	" 10	—	"	0.90	0.5	1.5	1.5	1.5	1.5	1.30	0.09, 0.04, 0.15, 0.43, 0.39.
100	" 18	—	"	0.90	1.0	1.0	1.0	1.5	1.5	1.20	
101	" 23	—	"	0.96	1.0	1.0	1.0	1.0	1.5	1.10	
102	Mar. 3	—	"	0.06	1.0	1.5	1.5	1.5	1.5	1.40	March 1896. 7th, 14th, 21st, 28th. Inches.
103	" 10	—	"	0.84	1.0	1.0	1.5	1.5	1.5	1.30	1.60, 0.65, 0.52, 0.86.
104	" 17	—	"	0.84	1.0	1.5	1.5	1.5	1.5	1.40	
105	" 24	—	"	0.84	1.0	1.0	1.0	1.5	1.5	1.20	
106	" 31	—	"	0.84	1.0	1.0	1.5	1.5	1.5	1.30	
107	April 7	—	"	0.84	0.5	1.5	1.5	1.5	1.5	1.30	April 1896. 4th, 11th, 18th, 25th. Inches.
108	" 14	—	"	0.78	0.5	1.0	1.5	1.5	1.5	1.20	0.26, 0.41, 0.43, 0.00.
109	" 21	—	"	0.84	1.0	1.5	1.5	1.5	2.0	1.50	
110	" 28	—	"	0.78	1.5	1.5	1.5	1.5	1.5	1.50	
111	May 5	—	"	0.84	0.5	1.0	1.5	1.5	1.5	1.20	May 1896. 2nd, 9th, 16th, 23rd, 30th. Inches.
112	" 12	—	"	0.84	1.5	1.5	1.5	1.5	1.5	1.50	0.45, 0.00, 0.00, 0.76, 0.00.
113	" 19	—	"	0.84	1.0	1.0	1.0	1.0	1.5	1.10	
114	" 26	—	"	0.84	1.0	1.0	1.0	1.5	1.5	1.20	
115	June 2	—	"	0.84	1.0	1.0	1.0	1.0	1.5	1.10	June 1896. 6th, 13th, 20th, 27th. Inches.
116	" 9	—	"	1.02	1.0	1.0	1.0	1.0	1.0	1.00	1.94, 1.23, 0.82, 0.47.
117	" 16	—	"	1.08	1.5	1.5	2.0	2.0	2.0	1.80	
118	" 23	—	"	0.96	1.0	1.0	1.0	1.0	1.0	1.00	
119	" 29	—	"	0.90	1.0	1.0	1.5	1.5	1.5	1.30	
120	July 7	—	"	0.84	1.0	1.5	1.5	1.5	1.5	1.40	July 1896. 4th, 11th, 18th, 25th. Inches.
121	" 14	—	"	0.96	1.0	1.5	1.5	1.5	1.5	1.40	0.27, 0.59, 0.08, 0.52.
122	" 21	—	"	0.96	1.5	1.5	1.5	1.5	1.5	1.50	
123	" 27	—	"	0.9	1.0	1.0	1.5	1.5	1.5	1.30	

TABLE LXXI.—*continued.*

Eldwick Reservoir Water.											
Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in terms of c.c. 10 <sup>3</sup> Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of Water. Phenol- phthalein used as Indicator.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Weekly Rainfall on the Gathering Ground.
					1st	2nd	3rd	4th	5th	Average.	
					50 c.c.	50 c.c.	50 c.c.	50 c.c.	50 c.c.		
124	1896. Aug. 4	—	Acid	0·06	1·0	1·5	1·5	1·5	1·5	1·40	August 1896. 1st, 8th, 15th, 22nd, 29th. Inches.
125	" 11	—	"	0·06	1·5	1·5	1·5	1·5	1·5	1·50	1·40, 0·08, 0·15, 0·16, 0·53.
126	" 18	—	"	0·84	1·0	1·5	1·5	1·5	1·5	1·40	September 1896. 5th, 12th, 19th, 26th. Inches.
127	Sept. 22	—	"	1·08	1·5	1·5	2·0	2·0	2·0	1·80	0·78, 0·79, 0·75, 2·11.
128	" 30	—	"	1·08	1·5	2·0	2·0	2·0	2·0	1·90	October 1896. Inches.
129	Oct. 6	—	"	1·02	1·5	2·0	2·0	2·0	2·0	1·90	3rd, 10th, 17th, 24th. 31st.
130	" 13	—	"	1·02	1·5	2·5	2·5	2·5	2·5	2·30	Inches.
131	" 20	—	"	0·06	1·5	1·5	1·5	1·5	1·5	1·50	0·60, 1·68, 1·02, 0·35, 0·78.
132	" 27	—	"	0·06	1·5	1·5	1·5	1·5	1·5	1·50	
133	Nov. 2	—	"	0·90	1·0	1·0	1·5	1·5	1·5	1·30	November 1896. 7th, 14th, 21st, 28th. Inches.
134	" 9	—	"	1·02	1·0	1·5	1·5	1·5	1·5	1·40	0·40, 1·12, 0·46, 0·11.
135	" 17	—	"	1·02	1·0	1·5	1·5	1·5	1·5	1·40	
136	" 24	—	"	1·26	2·0	2·0	2·5	2·5	2·5	2·30	
137	Dec. 1	—	"	0·06	1·5	1·5	1·5	1·5	1·5	1·50	December 1896. 5th, 12th, 19th, 26th, 31st.
138	" 8	—	"	0·06	1·5	1·5	1·5	1·5	2·0	1·60	Inches.
139	" 15	—	"	0·84	1·5	1·5	1·5	1·5	1·5	1·50	1·79, 1·17, 0·76, 0·19, 0·65.
140	" 22	—	"	0·06	1·5	1·5	1·5	2·0	2·0	1·70	
141	" 28	—	"	0·90	1·5	1·5	1·5	1·5	2·0	1·60	
142	1897. Jan. 5	—	"	0·06	1·0	1·5	1·5	1·5	1·5	1·40	January 1897. 7th, 14th, 21st, 28th. Inches.
143	" 13	—	"	0·84	1·5	1·5	1·5	1·5	1·5	1·50	1·22, 0·23, 0·18, 0·12.
144	" 18	—	"	0·06	1·5	1·5	1·5	1·5	1·5	1·50	
145	" 26	—	"	0·84	1·5	1·5	1·5	2·0	2·0	1·70	
146	Feb. 2	—	"	0·06	1·5	1·5	1·5	1·5	1·5	1·50	February 1897. 4th, 11th, 18th, 25th. Inches.
147	" 9	—	"	0·06	1·5	1·5	1·5	1·5	1·5	1·50	0·91, 0·62, 0·15, 0·82.
148	" 15	—	"	0·90	1·5	1·5	1·5	1·5	1·5	1·50	
149	" 23	—	"	0·90	1·0	1·5	1·5	2·0	2·0	1·60	
150	Mar. 2	—	"	0·84	1·5	1·5	1·5	2·0	2·0	1·70	March 1897. 4th, 11th, 18th. Inches.
151	" 9	—	"	0·72	1·5	1·5	1·5	1·5	1·5	1·50	1·47, 0·98, 1·77.
152	" 16	—	"	0·72	1·0	1·0	1·5	1·5	1·5	1·30	

It will be seen that no less than 152 samples were tested as regards acidity and plumbo-solvency, extending over a period of from February 27th, 1894, to March 16th, 1897. All the samples, without exception, were conspicuous, both as regards acidity and plumbo-solvent ability. The degree of acidity and plumbo-solvency did not vary very much from time to time, making it difficult to effect any comparison between amount of acidity and vigour of solvent action on lead, or between acidity and plumbo-solvency in relation to the season of the year or to fluctuations in the rainfall.

While on the subject of Shipley Waterworks it may not be amiss to include here Table LXXII., page 136, which deals with the acidity day by day of the three chief moorland streams, which together constitute the main source of supply.

It will be seen that samples were examined daily from February 18th, 1897, to March 21st, 1897. During this period Graincliffe, Blackdyke, and Weecher waters were always very acid, and the degree of acidity did not vary to any great extent.

Taking the three streams in the above order, the extremes were as follows:—

0.72 to 1.12; 0.96 to 1.24; 0.60 to 1.08 c.c.  $\frac{N}{10}$   $\text{Na}_2\text{CO}_3$ ,  
respectively, required to neutralise 100 c.c. of the water.

In the next table (Table LXXIII.), pages 138–141, the results of the chemical examination of Mossley Water (main water) are given.

It will be seen from the above table that Mossley water was uniformly slightly acid and dissolved lead to an appreciable extent. In other respects the results of its analysis were in no way peculiar. It was a “soft” water, containing a small proportion of solids, yielding low figures as regards chlorine, and, in comparison, high figures as regards albuminoid ammonia and oxygen absorbed from permanganate. The sustained laboratory experiments in connection with Shipley and Mossley waters thus lend additional support to the facts observed at Burnmoor, as to acidity and plumbo-solvency being correlated conditions, and as to plumbo-solvency being associated with no other ascertained condition except acidity.

TABLE LXXII.

Showing the ACIDITY Day by Day of certain MOORLAND STREAMS known as GRAINCLIFFE, BLACKDYKE, and WEECHER. SHIPLEY (ELDWICK) WATERWORKS.

Date.		Description of the Sample of Water.						Daily Rainfall (in Inches) on the Gathering Ground.
		Graincliffe.		Blackdyke.		Weecher.		
		A.		B.		C.		
		Reaction with Lacmoid.			Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.			
		A.	B.	C.	A.	B.	C.	
February 18th, 1897		—	—	—	—	—	—	0.00
" 19th, "		—	—	—	—	—	—	0.07
" 20th, "		—	—	—	—	—	—	0.05
" 21st, "		—	—	—	—	—	—	0.06
" 22nd, "		V. acid	V. acid	V. acid	0.84	0.99	0.84	0.00
" 23rd, "		"	"	"	0.84	0.96	0.84	0.00
" 24th, "		"	"	"	0.72	0.96	0.75	0.00
" 25th, "		"	"	"	0.72	0.96	0.84	0.08
" 26th, "		"	"	"	0.84	1.00	0.87	Accident to rain-gauge. 0.02
" 27th, "		"	"	"	0.75	0.99	0.84	
" 28th, "		"	"	"	0.72	0.98	0.72	
March 1st, 1897		"	"	"	0.96	1.08	0.87	0.16
" 2nd, "		"	"	"	—	1.08	0.87	0.18
" 3rd, "		"	"	"	1.08	1.08	0.87	0.58
" 4th, "		"	"	"	0.90	1.08	0.84	0.00
" 5th, "		"	"	"	1.08	1.08	0.88	0.55
" 6th, "		"	"	"	1.08	1.08	0.80	0.00
" 7th, "		"	"	"	0.96	1.08	0.84	0.09
" 8th, "		"	"	"	0.84	1.20	0.80	0.00
" 9th, "		"	"	"	0.84	1.22	0.84	0.00
" 10th, "		"	"	"	0.96	1.22	0.86	0.13
" 11th, "		"	"	"	0.84	1.22	0.84	0.04
" 12th, "		"	"	"	1.12	1.24	1.08	0.56
" 13th, "		"	"	"	1.08	1.23	1.00	0.16
" 14th, "		"	"	"	0.96	1.20	1.00	0.00
" 15th, "		"	"	"	0.84	1.23	1.09	0.85
" 16th, "		"	"	"	1.08	1.23	1.08	0.08
" 17th, "		"	"	"	1.08	1.23	1.08	0.33
" 18th, "		"	"	"	1.08	1.24	0.96	0.26
" 19th, "		"	"	"	1.10	1.24	0.96	0.22
" 20th, "		"	"	"	1.10	1.24	0.88	0.05
" 21st, "		"	"	"	0.96	1.23	0.88	0.01

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**TABLE LXXIII.**

Showing the **RECORD** of the **CHEMICAL EXAMINATION** of **WATER** obtained from the  
**TOWN of MOSSLEY (Main Water).**

**Results stated in Parts per 100,000.**

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TABLE

Showing the RECORD of the CHEMICAL EXAMINATION

Results stated in

Date of Examination.	Appearance.			Reaction with Lactmold.	Residue on Evaporation.			Ammonia		Oxidised Nitrogen.		Oxygen required for Organic Matter at 100° C.
	Colour.	Turbidity.	Residue.		Total.	Loss on Ignition.	Fixed.	Free.	Albumenoid.	Total.	As Nitrites.	
1893. Nov. 2	Yellow	Dim	Slight	Acid	11	5	6	*003	*024	*020	Nil	*47
" 10	"	"	"	"	11	5	6	*010	*019	*030	"	*37
" 16	"	"	"	"	12	5	7	*014	*014	*030	"	*28
" 20	"	Very cloudy.	Abundant	"	14	5	9	*016	*047	*053	"	1*17
" 27	"	"	Turbid	"	16	6	10	*010	*072	*066	"	*22
Dec. 4	"	Clear	Slight	"	14	5	9	*006	*007	*070	Trace	*15
" 9	"	Dim	"	"	10	4	6	*006	*074	*056	"	*33
" 14	"	Cloudy	"	"	9	3	6	*008	*016	*028	Nil	*16
" 20	"	"	"	"	8	4	4	*012	*006	*089	Trace	*92
1894. Jan. 2	"	"	"	"	10	4	6	*007	*014	*033	"	*25
" 10	"	"	"	"	10	4	6	*013	*013	*066	"	*14
" 18	"	"	"	"	9	4	5	*008	*012	*072	"	*32
" 26	"	"	"	"	12	4	8	*002	*014	*046	"	*17
Feb. 1	"	"	"	"	9	3	6	*002	*014	*066	"	*35
" 9	"	"	"	"	9	3	6	*005	*006	*072	"	*12
" 16	"	"	"	"	10	4	6	*010	*012	*108	"	*25
" 20	"	"	"	"	10	5	5	*009	*021	*098	"	*30
" 27	"	"	"	"	11	5	6	*006	*013	*078	Nil	*13
Mar. 6	"	"	"	"	10	5	5	*014	*011	*049	"	*25
" 10	"	"	"	"	10	6	4	*004	*018	*076	"	*13
" 22	"	Dim	"	"	10	4	6	*004	*013	*030	Trace	*16
" 31	"	"	"	"	9	5	4	*002	*014	*049	"	*15

## LXXIII.

of WATER obtained from the TOWN of MOSSLEY (Main Water).  
parts per 100,000.

Chlorine.	Hardness. Total.	Dissolved Oxygen.	Iron.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Plumbo-solvency, as shown by amount of Lead taken up in Samples. The action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Rainfall on Swineshaw Gathering Ground for the Weeks ended
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1'2	3'9	1'02	Present	0'54"	0'2	0'4	1'0	1'2	1'2	0'80	1893. Nov. 4 - 1'05 " 11 - 0'23 " 18 - 0'44 " 25 - 2'01
1'1	3'4	1'24	"	'42	0'6	0'4	0'6	0'6	0'6	0'56	
1'2	2'9	1'32	"	0'40	0'2	0'2	0'4	0'4	0'4	0'32	
1'1	3'2	1'32	"	0'50	0'2	0'4	0'4	0'6	0'6	0'44	
1'2	3'5	1'32	"	0'50	0'2	0'4	0'6	1'0	1'0	0'64	
1'1	3'2	1'46	"	0'24	0'2	0'2	0'4	0'2	0'2	0'24	Dec. 2 - 0'68 " 9 - 0'95 " 16 - 1'51 " 23 - 1'54 " 30 - 0'57
1'2	3'9	1'17	"	0'70	0'2	0'8	1'0	1'6	1'4	1'00	
1'1	3'8	1'28	"	0'36	0'1	0'1	0'2	0'3	0'3	0'20	
1'1	3'3	1'21	"	0'36	0'1	0'1	0'0	0'0	0'0	0'04	
1'1	4'6	1'33	"	0'30	0'0	0'2	0'3	0'4	0'4	0'26	1894. Jan. 6 - 0'05 " 13 - 0'46 " 20 - 1'47 " 27 - 1'07
1'1	4'2	1'41	"	0'36	0'0	0'0	0'1	0'2	0'3	0'12	
1'3	4'8	1'25	"	0'30	0'1	0'1	0'1	0'2	0'2	0'16	
1'1	3'8	1'35	"	0'30	0'1	0'1	0'1	0'1	0'2	0'12	
1'1	4'9	1'29	"	0'30	0'0	0'1	0'1	0'1	0'2	0'10	Feb. 3 - 1'10 " 10 - 2'06 " 17 - 1'13 " 24 - 0'48
1'1	3'5	1'24	"	0'24	0'0	0'0	0'1	0'1	0'2	0'08	
1'1	3'8	1'25	"	0'36	0'0	0'1	0'2	0'2	0'2	0'14	
1'3	3'5	1'46	"	0'36	0'0	0'1	0'2	0'2	0'3	0'16	
1'2	3'6	1'25	Nil	0'24	0'0	0'0	0'1	0'1	0'1	0'06	
1'2	4'2	1'20	"	0'36	0'1	0'1	0'3	0'4	0'0	0'30	Mar. 3 - 2'14 " 10 - 2'64 " 17 - 1'19 " 24 - 0'04 " 31 - 0'09
1'2	3'5	1'16	Present	0'36	0'1	0'1	0'2	0'4	0'4	0'24	
1'2	3'5	1'18	"	0'30	0'0	0'1	0'2	0'2	0'4	0'18	
1'1	4'2	1'17	"	0'36	0'0	0'1	0'2	0'3	0'4	0'30	



TABLE

Date of Examination.	Appearance.			Reaction with Lactmold.	Residue on Evaporation.			Ammonia.		Oxidised Nitrogen.		Oxygen required for Organic Matter at 100° C.
	Colour.	Turbidity.	Residue.		Total.	Loss on Ignition.	Fixed.	Free.	Albumenoid.	Total.	As Nitrates.	
1894.												
April 5	Yellow	Dim	Slight	Acid	10	3	7	·002	·010	·039	Nil	·27
" 12	"	"	"	"	8	3	5	·004	·020	·056	"	·20
" 18	"	"	"	"	9	4	5	·005	·011	—	Trace	·33
May 31	"	"	"	"	8	5	3	·003	·024	·099	"	·33
June 6	"	"	"	"	9	5	4	·007	·011	·020	Nil	·26
" 12	"	"	"	"	8	4	4	·008	·010	·043	"	·20
" 19	"	"	"	"	8	5	3	·003	·016	·036	"	·14
" 27	"	"	"	"	8	6	2	·007	·038	·040	"	·11
July 4	"	"	"	"	9	4	5	·007	·010	·053	"	·18
" 10	"	"	"	"	—	—	—	—	—	—	—	—
" 16	"	"	"	"	7	4	3	·004	·009	·052	Nil	·08
" 24	"	"	"	"	8	4	4	·012	·014	·039	Nil	·17
" 31	—	—	—	—	—	—	—	—	—	—	—	—
Aug. 7	Yellow	Dim	Slight	Acid	7	—	—	·006	·012	—	Nil	·24
" 14	—	—	—	—	—	—	—	—	—	—	—	—
" 21	Yellow	Dim	Slight	Acid	7	—	—	·014	·012	—	Nil	·14
" 28	"	"	"	"	10	—	—	·007	·010	—	"	·18
Sept. 4	"	"	"	"	7	—	—	·036	·012	—	—	·16

The chemical examination of this water, so far as acidity and plumbo-solvency are concerned,

## LXXIII.—continued.

Chlorine.	Hardness Total.	Dissolved Oxygen.	Iron.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Plumbo-solvency, as shown by amount of Lead taken up in Samples. The action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.							Rainfall on Swineshaw Gathering Ground for the Weeks ended	
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.			
1'2	3'5	1'13	Present	0'30	0'1	0'1	0'2	0'3	0'4	0'22	1894. April 7	Ins.	- 0'51
1'1	3'4	1'13	"	0'30	0'1	0'4	0'4	0'5	0'6	0'40	" 14	- 0'43	- 0'63
1'1	3'5	1'10	"	0'36	0'1	0'3	0'5	0'5	0'6	0'40	" 21	- 0'57	- 0'57
1'2	3'8	1'19	"	0'42	0'3	0'6	0'7	0'8	0'9	0'66	May 5	- 0'62	- 0'24
1'1	3'5	1'09	"	0'42	0'2	0'6	0'8	0'9	0'9	0'68	" 12	- 0'18	- 0'15
1'2	3'9	0'91	"	0'54	0'2	0'6	0'8	0'8	1'0	0'68	" 19	- 0'87	- 2'74
1'1	3'4	0'99	"	0'48	0'3	0'6	0'8	0'9	0'6	0'70	" 26	- 1'07	- 0'33
1'2	4'2	0'77	"	0'54	0'2	0'5	0'6	0'7	0'8	0'58	" 9	- 0'18	- 0'18
1'2	3'5	0'86	"	0'48	0'2	0'5	0'6	0'7	0'8	0'58	June 2	- 0'24	- 0'48
—	—	—	—	0'60	0'1	0'5	0'7	0'8	0'8	0'59	" 14	- 2'30	- 0'96
1'1	3'1	1'12	Present	0'42	0'1	0'4	0'5	0'6	0'6	0'44	" 21	- 0'38	- 1'33
1'1	3'4	0'88	Trace	0'42	0'0	0'3	0'5	0'6	0'7	0'42	" 28	- 0'24	- 1'40
—	—	—	—	0'42	0'1	0'4	0'5	0'6	0'6	0'42	July 7	- 1'32	- 1'33
1'1	3'5	—	Trace	0'48	0'1	0'4	0'6	0'8	0'9	0'56	Aug. 4	- 0'54	- 1'40
—	—	—	—	0'48	0'0	0'2	0'4	0'6	0'8	0'40	" 11	- 1'32	- 1'33
1'1	2'5	—	Trace	0'42	0'1	0'3	0'4	0'7	0'8	0'46	" 18	- 0'54	- 1'40
—	2'5	—	—	0'42	0'2	0'4	0'7	0'8	0'8	0'59	" 25	- 0'54	- 1'40
1'1	2'5	—	—	0'36	0'1	0'3	0'6	0'7	0'8	0'50	Sept. 1	- 0'08	- 0'38
—	—	—	—	—	—	—	—	—	—	—	" 8	- 0'38	- 0'38

was carried out beyond Sept. 4 1894. The results are given in Table LXXIV.

In the following table (Table LXXIV.) all the records as regards acidity and plumbo-solvency are included :—

TABLE LXXIV.

Showing the RESULTS of the CHEMICAL EXAMINATION of the WATER obtained from the TOWN of MOSSLEY\* (Main Water) as regards "HARDNESS," ACIDITY, and PLUMBO-SOLVENT ABILITY.

Mossley Main Water. Ashton, Stalybridge, and Dukinfield (District) Waterworks.											
Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in Terms of c.c. Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Rainfall on Swineshaw Gathering Ground for the Weeks ended
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	1893. Nov. 2	3.9	Acid.	0.54	0.2	0.4	1.0	1.2	1.2	0.80	November 1893. 4th, 11th, 18th, 25th. Inches.
2	" 10	3.4	"	0.48	0.6	0.4	0.6	0.6	0.6	0.56	1.06, 0.23, 0.44, 2.01.
3	" 16	2.9	"	0.40	0.2	0.2	0.4	0.4	0.4	0.32	
4	" 20	3.2	"	0.50	0.2	0.4	0.4	0.6	0.6	0.44	
5	" 27	3.5	"	0.50	0.2	0.4	0.6	1.0	1.0	0.64	
6	Dec. 4	3.2	"	0.24	0.2	0.2	0.4	0.2	0.2	0.24	December 1893. 2nd, 9th, 16th, 23rd, 30th.
7	" 9	3.9	"	0.70	0.2	0.8	1.0	1.6	1.4	1.00	Inches.
8	" 14	3.8	"	0.36	0.1	0.1	0.2	0.3	0.3	0.20	0.68, 0.08, 1.51, 1.54, 0.57.
9	" 20	3.2	"	0.36	0.1	0.1	0.0	0.0	0.0	0.04	
10	1894. Jan. 2	4.6	"	0.30	0.0	0.2	0.3	0.4	0.4	0.26	January 1894. 6th, 13th, 20th, 27th. Inches.
11	" 10	4.2	"	0.36	0.0	0.0	0.1	0.2	0.3	0.12	0.06, 0.46, 1.47, 1.07.
12	" 18	4.8	"	0.30	0.1	0.1	0.2	0.2	0.2	0.16	
13	" 26	3.8	"	0.30	0.1	0.1	0.1	0.1	0.2	0.12	
14	Feb. 1	4.9	"	0.30	0.0	0.1	0.1	0.1	0.2	0.10	February 1894. 3rd, 10th, 17th, 24th. Inches.
15	" 9	3.5	"	0.24	0.0	0.0	0.1	0.1	0.2	0.06	1.10, 2.06, 1.13, 0.48.
16	" 16	3.8	"	0.36	0.0	0.1	0.2	0.2	0.2	0.14	
17	" 20	3.5	"	0.36	0.0	0.1	0.2	0.2	0.3	0.16	
18	" 27	3.6	"	0.24	0.0	0.0	0.1	0.1	0.1	0.06	
19	Mar. 6	4.2	"	0.36	0.1	0.1	0.3	0.4	0.6	0.30	March 1894. 3rd, 10th, 17th, 24th, 31st.
20	" 10	3.5	"	0.36	0.1	0.1	0.2	0.4	0.4	0.24	Inches.
21	" 22	3.5	"	0.30	0.0	0.1	0.2	0.2	0.4	0.18	2.14, 2.64, 1.19, 0.04, 0.09.
22	" 31	4.2	"	0.36	0.0	0.1	0.2	0.3	0.4	0.20	
23	April 5	3.5	"	0.30	0.1	0.1	0.2	0.3	0.4	0.22	April 1894. 7th, 14th, 21st, 28th. Inches.
24	" 12	3.4	"	0.30	0.1	0.4	0.4	0.5	0.6	0.40	0.51, 0.43, 0.63, 0.57.
25	" 18	3.5	"	0.36	0.1	0.3	0.5	0.5	0.6	0.40	
26	May 31	3.8	"	0.42	0.3	0.6	0.7	0.8	0.9	0.66	May 1894. 5th, 12th, 19th, 26th. Inches.
											0.63, 1.24, 0.18, 0.15.

\* The town of Mossley is supplied with water from Lower Swineshaw Reservoir. Prior to December 1894 no "treatment" of the water was in operation. After that date and up to the present (1897), the water entering Lower Swineshaw has been "treated" with whiting, about 1½ grains to 1 gallon of water.

TABLE LXXIV.—*continued.*

Mossley Main Water. Ashton, Stalybridge, and Dukinfield (District) Waterworks.												
Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in Terms of c.c. of $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Average.	Rainfall on Swineshaw Gathering Ground for the Weeks ended
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.			
1894.												
27	June 6	3·3	Acid	0·42	0·2	0·6	0·8	0·9	0·9	0·68	June 1894.	
28	" 12	3·9	"	0·54	0·2	0·6	0·8	0·8	1·0	0·68	2nd, 9th, 16th, 23rd, 30th.	
29	" 19	3·4	"	0·43	0·3	0·6	0·8	0·9	0·9	0·70	Inches. 0·87, 2·74, 1·07, 0·33, 0·18.	
30	" 27	4·2	"	0·54	0·2	0·5	0·6	0·7	0·8	0·58		
31	July 4	3·5	"	0·48	0·2	0·5	0·6	0·7	0·8	0·58	July 1894.	
32	" 10	—	"	0·60	0·1	0·5	0·7	0·8	0·8	0·50	7th, 14th, 21st, 28th. Inches.	
33	" 16	3·1	"	0·42	0·1	0·4	0·5	0·6	0·6	0·44	0·24, 0·48, 2·30, 0·98.	
34	" 24	3·4	"	0·42	0·0	0·3	0·5	0·6	0·7	0·42		
35	" 31	—	"	0·42	0·1	0·4	0·5	0·6	0·6	0·42		
36	Aug. 7	3·5	"	0·48	0·1	0·4	0·6	0·8	0·9	0·56	August 1894.	
37	" 14	—	"	0·48	0·0	0·2	0·4	0·6	0·8	0·40	4th, 11th, 18th, 25th. Inches.	
38	" 21	2·8	"	0·42	0·1	0·3	0·4	0·7	0·8	0·46	2·54, 1·40, 1·32, 1·33.	
39	" 28	2·5	"	0·42	0·2	0·4	0·7	0·8	0·8	0·58		
40	Sept. 4	2·8	"	0·36	0·1	0·3	0·6	0·7	0·8	0·50	September 1894.	
41	" 11	2·8	"	0·42	0·2	0·5	0·6	0·8	0·8	0·58	1st, 8th, 15th, 22nd, 29th.	
42	" 18	3·5	"	0·48	0·2	0·4	0·6	0·8	0·9	0·58	Inches. 0·08, 0·38, Nil, 0·45, 0·19.	
43	" 25	3·2	"	0·42	0·3	0·7	0·8	0·9	0·9	0·70		
44	Oct. 2	3·2	"	0·48	0·2	0·6	1·0	1·0	1·2	0·80	October 1894.	
45	" 10	2·8	"	0·48	0·1	0·4	0·7	0·8	1·0	0·60	6th, 13th, 20th, 27th. Inches.	
46	" 16	2·8	"	0·42	0·2	0·6	0·8	0·9	1·0	0·70	0·15, 0·55, 1·63, 3·49.	
47	" 23	3·1	"	0·36	0·1	0·4	0·6	0·8	0·8	0·54		
48	" 30	3·5	"	0·36	0·0	0·1	0·2	0·4	0·5	0·24		
49	Nov. 6	3·8	"	0·42	0·1	0·4	0·5	0·6	0·6	0·44	November 1894.	
50	" 13	3·6	"	0·36	0·0	0·1	0·3	0·5	0·6	0·30	3rd, 10th, 17th, 24th. Inches.	
51	" 20	3·8	"	0·30	0·1	0·2	0·3	0·4	0·4	0·28	1·50, 1·40, 1·28, 0·19.	
52	" 27	3·5	"	0·30	0·1	0·4	0·4	0·4	0·5	0·36		
53	*Dec. 4	4·1	"	0·30	0·1	0·1	0·2	0·2	0·4	0·20	December 1894.	
54	" 11	3·5	"	0·36	0·0	0·1	0·1	0·2	0·2	0·12	1st, 8th, 15th, 22nd, 29th.	
55	" 18	3·5	"	0·36	0·2	0·4	0·6	0·8	0·8	0·56	Inches. 0·08, 0·38, 1·34, 2·41, 0·44.	
56	" 24	3·9	"	0·24	0·1	0·2	0·2	0·3	0·4	0·24		
1895.												
57	Jan. 8	4·1	"	0·30	0·1	0·1	0·2	0·2	0·3	0·18	January 1895.	
58	" 16	3·9	"	0·24	0·0	0·1	0·1	0·1	0·2	0·10	5th, 12th, 19th, 26th. Inches.	
59	" 23	3·9	"	Trace	0·0	0·0	0·0	0·1	0·1	0·04	0·23, Nil, 1·04, 1·22.	
60	" 31	3·8	"	0·24	0·0	0·1	0·1	0·1	0·2	0·10		

\* See note \* on preceding page.

TABLE LXXIV.—continued.

Experiment.	Mossley Main Water. Ashton, Stalybridge, and Dukinfield (District) Waterworks.										Rainfall on Swineshaw Gathering Ground for the Weeks ended
	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in Terms of c.c. 10 <sup>-10</sup> Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.					Average.	
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		
1895.											
61	Feb. 12	4.1	Acid	0.24	0.0	0.0	0.0	0.1	0.1	0.04	February 1895. 2nd, 9th, 16th, 23rd. Inches. Nil, Nil, Nil, 0.05.
62	" 19	5.6	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08	
63	" 26	4.1	"	0.18	0.1	0.1	0.1	0.1	0.1	0.10	
64	Mar. 5	5.2	"	0.30	0.0	0.0	0.1	0.1	0.2	0.08	March 1895. 2nd, 9th, 16th, 23rd. 30th. Inches. 0.63, 0.61, 0.17, 1.30, 1.96.
65	" 12	5.2	"	0.24	0.0	0.1	0.1	0.3	0.2	0.12	
66	" 19	4.8	"	0.24	0.1	0.1	0.1	0.2	0.2	0.14	
67	" 26	4.9	"	0.24	0.1	0.2	0.2	0.2	0.3	0.20	
68	April 3	5.0	Ft. acid	0.24	0.0	0.0	0.1	0.1	0.1	0.06	April 1895. 6th, 13th, 20th, 27th. Inches. 1.16, Nil, 0.26, 0.74.
69	" 11	5.2	"	0.24	0.0	0.0	0.1	0.1	0.1	0.06	
70	" 17	5.2	"	0.24	Trace	0.1	0.1	0.2	0.2	0.12	
71	" 23	4.6	"	0.24	0.0	0.0	0.1	0.2	0.2	0.10	
72	" 30	4.9	"	0.24	0.1	0.1	0.2	0.2	0.3	0.18	
73	May 7	5.2	"	0.24	0.1	0.2	0.2	0.2	0.3	0.20	May 1895. 4th, 11th, 18th, 25th. Inches. 0.53, Nil, 0.06, 0.71.
74	" 14	5.0	"	0.24	0.1	0.1	0.2	0.2	0.2	0.16	
75	" 21	5.3	"	0.24	0.1	0.2	0.2	0.2	0.2	0.18	
76	" 28	4.8	"	0.24	0.1	0.2	0.2	0.2	0.2	0.18	
77	June 4	5.0	"	0.24	0.1	0.1	0.1	0.1	0.2	0.12	June 1895. 1st, 8th, 15th, 22nd, 29th. Inches. 0.46, 0.06, 0.18, 0.06, 2.20.
78	" 11	5.2	Acid	0.36	0.1	0.2	0.2	0.3	0.3	0.22	
79	" 18	5.2	"	0.30	0.05	0.1	0.1	0.1	0.1	0.09	
80	" 25	4.9	"	0.30	0.1	0.2	0.2	0.2	0.3	0.20	
81	July 2	4.9	"	0.30	0.1	0.2	0.2	0.2	0.3	0.20	July 1895. 6th, 13th, 20th, 27th. Inches. 1.01, 0.91, 1.99, 5.23.
82	" 9	4.9	Ft. acid	0.24	0.0	0.1	0.1	0.1	0.1	0.08	
83	" 16	4.6	Trace acid	0.18	0.0	0.0	0.1	0.1	0.1	0.06	
84	" 23	4.9	"	0.24	0.0	0.1	0.1	0.1	0.1	0.08	
85	Aug. 2	4.9	"	0.15	0.0	0.0	0.1	0.1	0.1	0.06	August 1895. 3rd, 10th, 17th, 24th, 31st. Inches. 0.23, 1.34, 1.36, 0.31, 2.45.
86	" 7	4.6	Acid	0.30	0.1	0.1	0.1	0.2	0.2	0.14	
87	" 13	4.6	Ft. acid	0.24	0.1	0.2	0.2	0.2	0.3	0.20	
88	" 20	4.9	Acid	0.30	0.0	0.1	0.2	0.2	0.3	0.16	
89	" 27	5.0	"	0.36	0.1	0.2	0.2	0.2	0.3	0.20	
90	Sept. 3	4.9	"	0.30	0.2	0.2	0.3	0.3	0.3	0.26	September 1895. 7th, 14th, 21st, 28th. Inches. 1.23, 0.70, nil, nil. October 1895. 5th, 12th, 19th, 26th. Inches. 2.24, 0.86, 0.34, 0.68.
91	" 25	4.9	"	0.30	0.0	0.1	0.1	0.1	0.2	0.10	
92	Oct. 9	4.9	Ft. acid	0.24	0.0	0.1	0.1	0.1	0.1	0.08	
93	" 18	4.9	V. ft. trace acid.	0.18			Traces.				
94	" 23	4.9	Trace acid	0.24	0.0	0.1	0.1	0.1	0.1	0.08	
95	" 29	5.4	"	0.18	0.0	0.0	0.1	0.1	0.1	0.06	

TABLE LXXIV.—continued.

Mossley Main Water.  
Ashton, Stalybridge, and Dukinfield (District) Waterworks.

Experiment.	Date.	Hardness (CaCO <sub>3</sub> Parts per 100,000).	Reaction with Lacmoid.	Acidity in Terms of c.c. of $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Plumbo-solvency (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.						Average.	Rainfall on Swineshaw Gathering Ground for the Weeks ended
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.			
96	1895. Nov. 5	5.2	V.ft. trace acid.	0.18				Traces.				November 1895. 2nd, 9th, 16th, 23rd, 30th. Inches. 0.20, 0.59, 1.61, 0.40, 0.30.
97	" 12	—	"	0.18				Traces.				
98	" 19	—	"	0.18				Traces.				
99	" 26	—	"	0.18				Traces.				
100	Dec. 3	—	"	0.18				Traces.				December 1895. 7th, 14th, 21st, 28th. Inches. 1.79, 1.91, 0.02, 0.51.
101	" 17	—	Sl. acid	0.30	0.1	0.2	0.2	0.2	0.2	0.18		
102	" 24	—	"	0.24	0.1	0.2	0.2	0.2	0.3	0.20		
103	" 31	—	Ft. trace acid.	0.18				Traces.				
104	1896. Jan. 7	—	Trace	0.24	0.1	0.1	0.1	0.1	0.1	0.10		January 1896. 4th, 11th, 18th, 25th. Inches. 0.82, 0.10, 1.23, 0.46.
105	" 13	—	"	0.24	0.1	0.1	0.1	0.1	0.1	0.10		
106	" 22	—	"	0.24	0.1	0.1	0.1	0.1	0.1	0.10		
107	" 28	—	Sl. acid	0.30	0.0	0.1	0.2	0.2	0.2	0.14		
108	Feb. 4	—	"	0.30	0.1	0.1	0.2	0.2	0.2	0.16		February 1896. 1st, 8th, 15th, 22nd, 29th. Inches. 0.24, 0.56, 0.17, 0.23, 2.96.
109	" 11	—	"	0.30	0.1	0.3	0.3	0.3	0.3	0.26		
110	" 18	—	? Trace acid.	0.18				Traces.				
111	" 25	—	V.ft. trace acid.	0.18	0.0	0.0	0.1	0.1	0.1	0.06		
112	Mar. 3	—	"	0.18	0.0	0.0	0.1	0.1	0.1	0.06		March 1896. 7th, 14th, 21st, 28th. Inches. 2.42, 1.02, 1.01, 1.64.
113	" 10	—	"	0.18	0.0	0.0	0.1	0.1	0.1	0.06		
114	" 17	—	"	0.24	0.0	0.0	0.1	0.1	0.1	0.06		
115	" 24	—	"	0.24	0.0	0.0	0.1	0.1	0.1	0.06		
116	" 31	—	"	0.24	0.0	0.0	0.1	0.1	0.1	0.06		
117	April 8	—	Ft. acid	0.24	0.0	0.1	0.1	0.1	0.2	0.10		April 1896. 4th, 11th, 18th, 25th. Inches. 0.19, 0.52, 0.80, 0.18.
118	" 15	—	"	0.18	0.1	0.1	0.2	0.2	0.2	0.17		
119	" 22	—	"	0.18	0.0	0.1	0.1	0.1	0.1	0.06		
120	" 28	—	"	0.18	0.0	0.0	0.1	0.1	0.1	0.06		
121	May 6	—	"	0.18	0.1	0.1	0.1	0.1	0.1	0.10		May 1896. 2nd, 9th, 16th, 23rd, 30th. Inches. 0.70, nil, nil, 0.82, nil.

TABLE LXXV.—*continued.*

Number.	Description of the Sample of Water.	Date and Hour of testing the Sample of Water.	The Water was—		Reaction with Lacmoid.		
			Un-treated.	Treated with $\text{CaCO}_3$ at entry into Lower Swine-shaw Reservoir.	Distinctly Acid.	Slightly Acid.	Neutral or only very faintly Acid.
33	Mossley water, &c.— <i>continued.</i>	1894 Dec. 17, 10 a.m. -	—	Treated.	Distinctly Acid.	—	—
34		" 18, 4 p.m. -	—	"	"	—	—
35		" 19, 9 a.m. -	—	"	"	—	—
36		" 20, 11 " -	—	"	"	—	—
37		" 21, 10 " -	—	"	"	—	—
38		" 22, 4 p.m. -	—	"	"	—	—
39		" 23, 10 a.m. -	—	"	"	—	—
40		" 24, 10 " -	—	"	"	—	—
41		" 25, 9 " -	—	"	"	—	—
42		" 26, 11 " -	—	"	"	—	—
43		" 27, 10 " -	—	"	—	Slightly acid.	—
44		" 28, 12 p.m. -	—	"	—	"	—
45		" 29, 9 " -	—	"	—	"	—
46		" 30, 4 " -	—	"	—	"	—
47		" 31, 9 a.m. -	—	"	—	"	—
48		1895. Jan. 1, 10 a.m. -	—	"	—	"	—
49		" 2, 3 p.m. -	—	"	—	—	Neutral or only very faintly Acid.
50		" 3, 10 a.m. -	—	"	—	Slightly acid.	—
51		" 4, 11 " -	—	"	—	"	—
52		" 5, 10 " -	—	"	—	"	—
53		" 6, 10 " -	—	"	—	"	—
54		" 7, 10 " -	—	"	—	—	Neutral or only very faintly Acid.
55		" 8, 10 " -	—	"	—	—	"
56		" 9, 6 p.m. -	—	"	—	—	"
57		" 10, 10 a.m. -	—	"	—	—	"
58		" 11, 10 " -	—	"	—	Slightly acid.	—
59		" 12, 12 p.m. -	—	"	—	"	—
60		" 13, 10 a.m. -	—	"	—	"	—
61		" 14, 5 p.m. -	—	"	—	"	—
62		" 15, 10 a.m. -	—	"	—	"	—
63		" 16, 11 " -	—	"	—	"	—

TABLE LXXV.—*continued.*

Number.	Description of the Sample of Water.	Date and Hour of testing the Sample of Water.	The Water was—		Reaction with Lacmoid.		
			Un-treated.	Treated with $\text{CaCO}_3$ at entry into Lower Swinshaw Reservoir.	Distinctly Acid.	Slightly Acid.	Neutral or only very faintly Acid.
64	Mossley water, &c.— <i>continued.</i>	1895 Jan. 17, 10 a.m. -	—	Treated.	—	Slightly acid.	—
65		" 18, 9 " -	—	"	—	"	—
66		" 19, 4 p.m. -	—	"	—	"	—
67		" 20, 10 a.m. -	—	"	—	—	Neutral or only very faintly Acid.
68		" 21, 10 " -	—	"	—	—	"
69		" 22, 4 p.m. -	—	"	—	—	"
70		" 23, 10 a.m. -	—	"	—	Slightly acid.	—
71		" 24, 10 " -	—	"	—	—	Neutral or only very faintly Acid.
72		" 25, 10 " -	—	"	—	—	"
73		" 26, 4 p.m. -	—	"	—	—	"
74		" 27, 9 a.m. -	—	"	—	—	"
75		" 28, 10 " -	—	"	—	—	"
76		" 29, 4 p.m. -	—	"	—	—	"
77		" 30, 10 a.m. -	—	"	—	—	"
78		" 31, 3 p.m. -	—	"	—	—	"
79		Feb. 1, 9 a.m. -	—	"	—	—	"
80		" 2, 11 " -	—	"	—	—	"
81		" 3, 10 " -	—	"	—	—	"
82		" 4, 1 p.m. -	—	"	—	—	"
83		" 5, 10 a.m. -	—	"	—	—	"
84		" 6, 10 " -	—	"	—	—	"
85		" 7, 10 " -	—	"	—	—	"
86		" 8, 5 p.m. -	—	"	—	—	"
87		" 9, 3 " -	—	"	—	—	"
88		" 10, 10 a.m. -	—	"	—	—	"
89		" 11, 4 p.m. -	—	"	—	—	"
90		" 12, 7 " -	—	"	—	—	"
91		" 13, 12 p.m. -	—	"	—	—	"
92		" 14, 11 a.m. -	—	"	—	—	"
93		" 15, 5 p.m. -	—	"	—	—	"



TABLE LXXVI.

Showing the Result of the Examination, as regards Acidity and PLUMBO-SOLVENT ABILITY, of the "INLET" WATER to and the "OUTLET" WATER from SHEEPHOUSE RESERVOIR (Bacup Corporation Waterworks). The Records of the Rainfall were obtained from the nearest available source, there being no Rain-gauge on the Bacup Gathering Ground.

Experiment.	Description of the Sample of Water.	Reaction with Lactmoid.	Acidity in Terms of cc. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 cc. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead shot at the rate of 3 mins. per 50 c.c.					Rainfall (Weekly) at Naden Dean, Gauge 949.19 feet above Sea Level.
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1a	June 30th, 1896. "Inlet" water to Sheephouse Reservoir	? Trace acid	0.18	0.1	0.1	0.1	0.1	0.1	June 1896. 5th, 13th, 19th, 26th, 30th. Inches. 0.51, 0.40, 0.77, 0.76, 0.88.
1b	" " "Outlet" " from "	V. acid	0.54	0.8	1.4	1.4	1.6	1.6	
2a	July 7th, " " "Inlet" " to "	? Trace acid	0.18	0.2	0.5	Traces.	1.0	1.2	
2b	" " " "Outlet" " from "	V. acid	0.60	0.1	0.1	0.1	0.1	0.1	July 1896. 3rd, 10th, 17th, 24th, 31st. Inches. 0.12, 0.80, 0.00, 1.15, 0.49.
3a	" 14th, " " "Inlet" " to "	? Trace acid	0.20	0.1	0.1	0.1	0.1	0.1	
3b	" " " "Outlet" " from "	V. acid	0.60	1.0	1.4	1.6	1.6	1.6	
4a	Aug. 4th, " " "Inlet" " to "	? Trace acid	0.18	0.1	0.1	0.1	0.1	0.1	August 1896. 7th, 14th, 21st, 28th. Inches. 0.01, 0.35, 0.65, 1.96.
4b	" " " "Outlet" " from "	V. acid	0.60	0.6	1.0	1.4	1.4	1.4	
5a	" 18th, " " "Inlet" " to "	? Trace acid	0.18	0.6	1.0	Traces.	1.0	1.0	
5b	" " " "Outlet" " from "	V. acid	0.60	0.6	1.0	1.0	1.0	1.0	September 1896. 4th, 11th, 18th, 25th. Inches. 1.35, 0.53, 1.97, 3.53.
6a	Sept. 18th, " " "Inlet" " to "	"	0.60	1.0	1.2	1.2	1.2	1.2	
6b	" " " "Outlet" " from "	"	0.96	1.6	2.4	2.6	2.6	2.6	

7a	" 22nd, "	" "Inlet" "	" to	" "	0'84	1'0	2'0	2'0	2'0	2'0	2'0	1'80
7b	" " "	" "Outlet" "	" from	" "	1'08	1'6	3'0	3'0	3'0	3'0	3'0	2'73
8a	" 29th, "	" "Inlet" "	" to	" "	0'72	0'4	0'8	1'0	1'0	1'0	1'0	0'84
8b	" " "	" "Outlet" "	" from	" "	0'88	1'2	2'0	2'0	2'0	2'0	2'0	1'84
9a	Oct. 6th, "	" "Inlet" "	" to	" "	0'72	0'6	0'8	0'8	0'8	0'8	0'8	0'72
9b	" " "	" "Outlet" "	" from	" "	0'96	0'8	1'6	1'6	2'0	2'0	2'0	1'60
10a	" 13th, "	" "Inlet" "	" to	" "	1'08	1'4	2'4	2'4	2'4	2'4	2'4	2'20
10b	" " "	" "Outlet" "	" from	" "	0'72	1'0	1'2	1'2	1'6	1'6	1'6	1'32
11a	" 20th, "	" "Inlet" "	" to	" "	0'84	1'2	2'0	2'4	2'4	2'4	2'4	2'08
11b	" " "	" "Outlet" "	" from	" "	0'66	0'8	1'2	1'6	1'6	1'6	1'6	1'36
12a	" 27th, "	" "Inlet" "	" to	" "	0'72	0'8	1'2	1'6	1'6	2'0	2'0	1'44
12b	" " "	" "Outlet" "	" from	" "	0'60	0'4	1'2	1'2	1'6	1'6	1'20	
13a	Nov. 2nd, "	" "Inlet" "	" to	" "	0'48	0'6	1'2	1'2	1'2	1'2	1'2	1'08
13b	" " "	" "Outlet" "	" from	" "	0'63	0'6	1'4	1'6	1'6	1'6	1'36	
14a	" 9th, "	" "Inlet" "	" to	" "	0'72	0'6	0'8	1'2	1'2	1'2	1'00	
14b	" " "	" "Outlet" "	" from	" "	0'75	0'4	0'8	1'2	1'2	1'2	0'96	
15a	" 17th, "	" "Inlet" "	" to	" "	1'20	1'2	2'0	2'0	2'4	2'4	1'62	
15b	" " "	" "Outlet" "	" from	" "	0'84	0'6	1'2	1'4	1'4	1'6	1'24	
16a	" 24th, "	" "Inlet" "	" to	" "	0'84	0'8	1'2	1'2	1'2	1'2	1'12	
16b	" " "	" "Outlet" "	" from	" "	0'96	0'8	1'2	1'2	1'4	1'4	1'20	

October 1892.  
2nd, 9th, 14th, 23rd, 30th.  
Inches.  
1'19, 2'72, 0'56, 1'40, 0'63.

November 1893.  
6th, 13th, 20th, 27th.  
Inches.  
0'11, 0'31, 0'59, 0'06.

October 1893.  
2nd, 6th, 16th, 23rd, 30th.  
Inches.  
1'19, 2'72, 0'58, 1'40, 0'68.

November 1893.  
6th, 13th, 20th, 27th.  
Inches.  
0'11, 0'91, 0'39, 0'06.

TABLE LXXVI.—continued.

Experiment.	Description of the Sample of Water.	Reaction with Lacomoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.					Rainfall (Weekly) at Naden Dean. Gauge 943.19 feet above Sea Level.
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
17a	Dec. 1st, 1896. "Inlet" water to Sheephouse Reservoir	Trace acid	0.20	0.4	0.8	0.8	1.0	1.0	0.80
17b	" " " " " " " " " " " "	V. acid	0.60	1.6	2.4	2.4	2.4	2.8	2.32
18a	" 8th, " " " " " " " " " "	"	1.08	0.6	1.2	1.2	1.2	1.2	1.08
18b	" " " " " " " " " " " "	"	0.72	1.2	2.0	2.0	2.4	2.4	2.00
19a	" 15th, " " " " " " " " " "	"	0.96	0.8	1.2	1.4	1.6	1.6	1.32
19b	" " " " " " " " " " " "	"	0.72	0.2	0.2	0.4	0.4	0.4	0.32
20a	" 22nd, " " " " " " " " " "	Sl. acid	0.30	0.6	0.8	1.2	1.2	1.2	1.00
20b	" " " " " " " " " " " "	V. acid	0.60	0.8	1.4	1.4	1.4	1.6	1.32
21a	" 28th, " " " " " " " " " "	"	0.66	1.6	2.0	2.0	2.0	2.0	1.92
21b	" " " " " " " " " " " "	"	0.90	0.6	1.0	1.2	1.2	1.2	1.04
22a	Jan. 5th, 1897. "Inlet" " " " " " "	"	0.58	0.6	1.0	1.2	1.2	1.4	1.08
22b	" " " " " " " " " " " "	"	0.63	1.0	1.6	1.6	1.6	1.6	1.48
23a	" 13th, " " " " " " " " " "	"	0.78	0.6	0.8	1.0	1.2	1.2	0.96
23b	" " " " " " " " " " " "	"	0.60	0.4	0.8	0.8	0.8	0.8	0.72
24a	" 18th, " " " " " " " " " "	"	0.48	0.6	1.2	1.2	1.2	1.2	1.12
24b	" " " " " " " " " " " "	"	0.68	0.8	1.2	1.2	1.2	1.2	1.12

December 1896.  
4th, 11th, 15th, 26th.  
1.13, 1.16, 0.67, 1.17.

Jan. 1897.  
1st, 8th, 15th, 23rd, 29th.  
Inches.  
2.12, 1.08, 0.08, 0.07, 0.42.



The foregoing table shows the results of the examination, as regards acidity and plumbo-solvent ability, of the "inlet" water to and the "outlet" water from Sheephouse Reservoir. It is to be noted that all the samples of "outlet" water were very acid and acted strongly on lead. The "inlet" was usually also very acid and possessed of strong plumbo-solvent ability; but some times the samples were only feebly acid and dissolved lead to a correspondingly slighter extent than was otherwise the case. As the inlet water referred to is the only water gaining access to Sheephouse Reservoir the results are of considerable interest. On other occasions, the inlet water was more acid than the outlet water, and also acted more markedly on lead. The experiments cover a period of about nine months, viz., from June 30th, 1896, to March 23rd, 1897. They illustrate very well a point on which great stress has been laid in Volume I., namely, that at times the inlet water to a reservoir may be much less acid and possessed also of far weaker solvent action on lead than the water in the reservoir itself. At other times the conditions may be reversed, *i.e.*, the inlet water may be more acid and possessed of a higher degree of plumbo-solvency than the reservoir water. The former of these opposite conditions is apt to hold with a water small in bulk (dry weather flow) and the latter with a comparatively large volume (storm water).

There remains for consideration Settle Peat Pool water. This water was derived from a pool in the peat on moorland, in the neighbourhood of Settle. The results, as regards acidity and plumbo-solvency, are shown in the following table (Table LXXVII.) :—

TABLE LXXVII.

Showing the AMOUNT of the ACIDITY and the PLUMBO-SOLVENT ABILITY of WATER obtained from "SETTLE PEAT POOL."

SETTLE PEAT POOL WATER.								
Experiment.	Date.	Acidity in Terms of $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Plumbo-solvent ability tested by upward filtration through 50 c.c. washed Lead Shot at a uniform Rate of 3 minutes per 50 c.c. (Results stated as Parts per 100,000.)					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	January 19, 1894	0.48	0.4	0.8	1.0	1.0	1.0	0.84
2	January 22, 1894	0.96	0.6	1.8	2.2	2.2	2.2	1.60
3	January 23, 1894	1.30	0.6	2.0	2.2	2.2	2.2	1.84
4	January 25, 1894	0.48	0.1	0.3	0.5	0.5	0.5	0.38
5	January 29, 1894	1.08	No record.					
6	January 30, 1894	0.48	No record.					
7	February 3, 1894	0.36	0.0	0.1	0.3	0.5	0.6	0.30
8	February 5, 1894	0.36	0.0	0.1	0.2	0.3	0.3	0.18
9	February 8, 1894	0.36	0.1	0.2	0.4	0.5	0.6	0.36
10	February 14, 1894	0.84	0.6	1.4	1.6	1.6	1.8	1.40
11	February 24, 1894	0.60	0.4	1.0	1.2	1.2	1.2	1.00
12	February 28, 1894	0.60	0.4	0.9	1.0	1.2	1.2	0.94
13	March 2, 1894	0.00	0.2	0.4	1.0	1.2	1.2	0.80
14	March 9, 1894	0.60	0.4	1.0	1.4	1.4	1.5	1.14
15	March 19, 1894	0.66	0.3	1.1	1.2	1.4	1.6	1.12
16	June 5, 1894	0.48	0.0*	0.2	0.2	0.2	0.2	0.16

\* The water was turbid and had to be filtered before the plumbo-solvent ability could be tested. Filtration lessens the power of acting on lead.

These results show that the water was always acid and dissolved lead to a considerable extent. The acidity varied from time to time, and the plumbo-solvent ability may be said broadly to vary in correspondence with the degree of acidity.

Passing now to the effect, as regards plumbo-solvency, of the addition to moorland waters of various substances, and of placing moorland waters under a number of different conditions, it should be noted that the question of the relation of acidity to plumbo-solvent ability is not lost sight of; but on the contrary is illustrated in a striking manner, and in a variety of ways throughout the tables about to be considered. At the same time the results dealt with in the various tables will be found to bear more or less directly on the question of the best remedial measures to be adopted in order to correct the acidity and plumbo-solvent ability of moorland waters.

In Tables LXXVIII. and LXXIX. the effect, as regards plumbo-solvency, of keeping Shipley and Mossley waters in partially filled and unstoppered bottles is set forth in detail.

TABLE LXXVIII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of keeping SHIPLEY WATER in PARTIALLY FILLED and UNSTOPPERED BOTTLES.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of Experiment.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Shipley water, April 3rd, 1894	2'0	2'5	3'0	3'0	3'0	2'70
	" " after 50 days	2'0	3'0	3'0	3'0	3'0	2'80
2	" " April 9th, 1894	1'0	2'5	3'0	3'0	3'0	2'50
	" " after 50 days	1'5	3'0	3'0	3'0	3'0	2'70
3	" " May 28th, 1894	1'0	2'0	2'0	2'0	3'0	2'00
	" " after 18 days	1'5	2'0	3'0	3'0	3'0	2'50
4	" " June 11th, 1894	1'5	3'0	3'0	3'0	4'0	2'90
	" " after 24 days	2'5	3'0	3'5	3'5	4'0	3'30
	" " after 45 days	2'0	3'0	3'5	3'5	3'5	3'10
	" " after 61 days	1'5	3'0	3'0	3'0	4'0	2'90
5	" " June 18th, 1894	1'5	3'0	3'5	4'0	4'0	3'20
	" " after 39 days	1'0	2'0	2'5	2'5	2'0	2'00
	" " after 114 days	0'75	1'5	1'75	2'0	2'25	1'65
6	" " June 25th, 1894	2'0	3'0	3'0	3'5	3'0	2'90
	" " after 32 days	0'5	2'0	2'5	3'0	3'0	2'20
	" " after 235 days	0'5	1'0	1'25	1'25	1'25	1'05
7	" " July 2nd, 1894	2'0	3'0	3'0	3'0	3'0	2'90
	" " after 25 days	0'5	2'0	3'0	3'0	3'5	2'40
	" " after 238 days	0'25	0'5	1'5	1'5	1'5	1'05

The first four experiments in Table LXXVIII. seem to indicate that storage under the specified conditions for 50, 50, 13, and 61 days cannot be relied on to alter appreciably the plumbo-solvent ability of Shipley water. The last three experiments showed that storage for 114, 235, and 228 days did, indeed, to a material extent, reduce plumbo-solvency, but the water was still left in a dangerous condition as far as solvent action on lead is concerned.

TABLE LXXIX.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of keeping MOSSLEY WATER in PARTIALLY FILLED and UNSTOPPERED BOTTLES.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of Experiment.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Mossley water, March 30th, 1894 - -	0'0	0'1	0'2	0'3	0'4	0'20
	" " after 54 days - - -	0'1	0'3	0'3	0'4	0'4	0'30
2	Mossley water, April 11th, 1894 - -	0'1	0'4	0'4	0'5	0'6	0'40
	" " after 43 days - - -	0'1	0'2	0'3	0'4	0'4	0'28
3	Mossley water, May 28th, 1894 - -	0'3	0'6	0'7	0'8	0'9	0'66
	" " after 25 days - - -	0'1	0'5	0'6	0'8	0'8	0'56
	" " after 56 days - - -	0'1	0'2	0'3	0'4	0'5	0'30
	" " after 74 days - - -	0'0	0'2	0'4	0'4	0'4	0'28
4	Mossley water, June 5th, 1894 - - -	0'2	0'6	0'8	0'9	0'9	0'68
	" " after 52 days - - -	0'0	0'2	0'4	0'6	0'7	0'38
	" " after 74 days - - -	0'1	0'2	0'3	0'4	0'4	0'28
5	Mossley water, June 11th, 1894 - -	0'2	0'6	0'8	0'8	1'0	0'68
	" " after 46 days - - -	0'0	0'1	0'1	0'2	0'2	0'12
	" " after 68 days - - -	0'0	0'0	0'0	0'1	0'2	0'06
	" " after 103 days - - -	0'0	0'0	0'0	0'1	0'2	0'06
6	Mossley water, June 18th, 1894 - -	0'3	0'6	0'8	0'9	0'9	0'70
	" " after 31 days - - -	0'0	0'2	0'3	0'5	0'4	0'28
	" " after 114 days - - -	0'0	0'2	0'3	0'4	0'4	0'28
7	Mossley water, June 26th, 1894 - -	0'2	0'5	0'6	0'7	0'8	0'56
	" " after 31 days - - -	0'0	0'1	0'3	0'3	0'4	0'22
	" " after 171 days - - -	0'0	0'1	0'1	0'2	0'2	0'12
8	Mossley water, July 3rd, 1894 - -	0'2	0'5	0'6	0'7	0'8	0'56
	" " after 24 days - - -	0'0	0'2	0'3	0'4	0'5	0'28
	" " after 165 days - - -	Traces	Traces	Traces	Traces	Traces	Traces.

The foregoing parallel series of experiments made with Mossley water were on the whole of a more encouraging nature, but they do not seem to indicate that even prolonged storage could ever be relied on to eliminate, to any practical extent, the danger of a naturally plumbo-solvent water retaining in some measure its original solvent action on lead.

The importance of these observations is obvious, since it has a direct bearing on the question of the storage in reservoirs of moorland waters. The advantages of a large storage capacity in connection with the storage reservoirs on moorland gathering grounds, and also the service reservoirs may, without question, be admitted; but the above results do not seem to show that reliance could be placed on storage alone to remove the plumbo-solvent ability of moorland waters.

In the following table (Table LXXX.) the effect, as regards plumbosolvency, of various temperatures upon different acid waters, is shown:—

TABLE LXXX.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of various TEMPERATURES upon different ACID WATERS.

[Tested by upward filtration, through washed shot, at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Temperature of the Water (Degrees Centigrade).	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) Distilled water acidified with HCl.	3	0.4	0.6	0.8	0.8	0.8	0.68
	(b.) " " " "	13	0.4	0.6	0.9	0.9	1.1	0.76
	(c.) " " " "	25	0.1	0.1	0.3	0.4	0.6	0.30
2	(a.) Settle Peat Pool, January 25, 1894.	7	0.1	0.3	0.5	0.5	0.5	0.38
	(b.) " " " "	23	0.0	0.2	0.5	0.5	0.5	0.34
3	(a.) Distilled water acidified with $H_2SO_4$ .	3	0.1	0.3	0.8	0.8	1.0	0.60
	(b.) " " " "	30	0.1	0.4	0.8	0.8	1.0	0.62
4	(a.) Distilled water acidified with $H_2SO_4$ .	4	2.0	2.4	2.4	2.4	2.4	2.32
	(b.) " " " "	25	2.0	2.6	2.6	2.6	2.8	2.52
5	(a.) Shipley water, August 13th, 1894.	3	1.0	2.0	2.5	2.5	2.5	2.10
	(b.) " " " "	10	1.0	2.5	3.0	3.0	3.0	2.50
	(c.) " " " "	15	1.0	2.5	3.0	3.0	2.0	2.10
	(d.) " " " "	20	0.5	2.0	3.0	3.0	2.5	2.20
	(e.) " " " "	30	0.5	2.5	2.5	2.5	2.5	2.10
	(f.) " " " "	50	0.0	0.4	0.8	0.8	0.9	0.58
6	(a.) Mossley water, August 14th, 1894.	3	0.0	0.4	0.8	0.8	0.9	0.58
	(b.) " " " "	10	0.0	0.2	0.5	0.6	0.8	0.42
	(c.) " " " "	16	0.0	0.2	0.4	0.6	0.8	0.40
	(d.) " " " "	20	0.0	0.3	0.6	0.6	0.8	0.46
	(e.) " " " "	30	0.0	0.4	0.6	0.8	0.8	0.52
	(f.) " " " "	50	0.0	0.4	0.8	1.0	1.0	0.64



The results were not always uniform in character; but they seem, on the whole, to indicate that temperature is not a very important factor in determining the vigour of solvent action on lead of acid waters.

**Table LXXXI.** shows the effect, as regards plumbo-solvency, of the continuous passage of different acid waters by upward filtration through lead shot.

**TABLE LXXXI.**

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the continuous passage of different ACID WATERS by upward filtration through LEAD SHOT.

Experiment.	Description of the Experiment.	Action on Lead (Results stated as Parts per 100,000). Each 50 c.c. of filtrate examined in succession, unless otherwise stated.
1	Distilled water X (acid reaction). The water was filtered continuously at a uniform rate of 3 minutes per 50 c.c. through 25 c.c. lead shot by upward filtration. 1,600 c.c. filtered.	.0 .2 .3 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4 .4
2	Settle Peat Pool, February 8th, 1894. The water was filtered continuously at a uniform rate of 3 minutes per 50 c.c. through 50 c.c. lead shot by upward filtration. 1,300 c.c. filtered.	.1 .2 .5 .6 .6 .7 .8 .8 .8 .7 .7 .8 .9 .8 .9 .8 .8 .8 .8 .9 .8 .8 .8 .8 .8 .8 .8 .8 .8 .8 .8 .8
3	Distilled water X (acid reaction), July 5th, 1894. The water was filtered continuously through 50 c.c. shot at a uniform rate of 3 minutes per 50 c.c. 1,350 c.c. filtered.	.2 .4 .5 .5 .6 .6 .7 .6 .5 .5 .7 .6 .6 .6 .7 .7 .7 .6 .6 .6 .5 .6 .6 .6 .6 .6 .6 .6 .6 .6 .6 .6
4	Shipley water, July 9th, 1894. The water was filtered continuously through 5 c.c. shot at a uniform rate of 2½ minutes per 50 c.c. 3,000 c.c. were filtered.	Every fifth 50 c.c. tested for lead. ..... 1.2 ..... 1.2 ..... 1.2 ..... 1.2 ..... 1.2 ..... 1.2 ..... 1.2 ..... 1.2 ..... 1.2 ..... 1.0 ..... 1.0 ..... 1.0
5	Mossley water, July 10th, 1894. The water was filtered continuously through 10 c.c. shot at a uniform rate of 2½ minutes per 50 c.c. 3,600 c.c. filtered.	Every ninth 50 c.c. tested for lead. ..... .0.4 ..... .0.5 ..... ..... .0.5 ..... .0.4 ..... ..... .0.5 ..... .0.5 ..... ..... .0.5 .....
6	Shipley water, July 30th, 1894. The water was filtered continuously through 5 c.c. shot at a uniform rate of 2½ minutes per 50 c.c. 2,250 c.c. filtered.	Every fifth 50 c.c. tested for lead. ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.0 .....
7	Mossley water, July 31st, 1894. The water was filtered continuously through 50 c.c. shot at a uniform rate of 3 minutes per 50 c.c. 2,750 c.c. filtered.	Every fifth 50 c.c. tested for lead. ..... .0.6 ..... .0.7 ..... .0.8 ..... .0.9 ..... .0.9 ..... .0.9 ..... 1.0 ..... .0.8 ..... 1.0 ..... 1.0 ..... 1.0 .....
8	Shipley water, September 17th, 1894. The water was filtered continuously through 5 c.c. shot at a uniform rate of 2½ minutes per 50 c.c. 2,750 c.c. filtered.	Every fifth 50 c.c. tested for lead. ..... 1.6 ..... 1.3 ..... 1.4 ..... 1.4 ..... 1.2 ..... 1.2 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.2 .....
9	Mossley water, September 18th, 1894. The water was filtered continuously through 25 c.c. shot at a uniform rate of 3 minutes per 50 c.c. 3,250 c.c. filtered.	Every fifth 50 c.c. tested for lead. ..... .0.8 ..... .0.7 ..... .0.8 ..... .0.8 ..... .0.8 ..... 1.0 ..... .0.9 ..... .0.8 ..... .0.8 ..... .0.8 ..... .0.8 ..... .0.8 ..... .0.8 .....
10	Shipley water, September 25th, 1894. The water was filtered continuously through 5 c.c. shot at a uniform rate of 2½ minutes per 50 c.c. 2,250 c.c. filtered.	Every fifth 50 c.c. tested for lead. ..... 2.0 ..... 2.0 ..... 2.0 ..... 1.5 ..... 1.5 ..... 1.0 ..... 1.0 ..... 1.0 ..... 1.5 .....
11	Mossley water, September 25th, 1894. The water was filtered continuously through 25 c.c. shot at a uniform rate of 3 minutes per 50 c.c. 2,500 c.c. filtered.	Every fifth 50 c.c. tested for lead. ..... .0.6 ..... .0.6 ..... .0.4 ..... .0.6 ..... .0.5 ..... .0.6 ..... .0.6 ..... .0.5 ..... .0.6 ..... .0.5 .....

The results show that, after the first few filtrates had been collected, the water dissolved proportionately about the same amount of lead throughout the remainder of the experiment. There was no evidence of any sensible reduction in the amount of lead dissolved by the water, even when over 3,000 c.c. had passed through the same shot.

In the following table (Table LXXXII.) the effect, as regards plumbo-solvency, of the rate of filtration through lead shot of various acid waters is shown :—

TABLE LXXXII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the RATE of FILTRATION through LEAD SHOT of various ACID WATERS.

[The action on lead was tested by upward filtration through 50 c.c. washed shot.]

Experiment.	Description of the Sample of Water.	Average rate of filtration (in minutes) per 50 c.c.	Action on Lead (Results expressed as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) Distilled water, acid -	3	0.1	0.3	0.3	0.3	0.3	0.26
	(b.) " " -	14	0.1	0.3	0.3	0.3	0.3	0.26
2	(a.) Distilled water, acid -	2	1.0	1.6	1.2	2.0	1.4	1.44
	(b.) " " -	3	1.4	1.8	2.0	2.0	2.2	1.88
	(c.) " " -	6	1.0	1.8	2.0	2.0	2.0	1.76
	(d.) " " -	44	0.3	1.0	1.0	1.0	1.0	0.86
3	(a.) Settle Pond Pool, January 23rd, 1894.	3	0.6	2.0	2.2	2.2	2.2	1.84
	(b.) " " " -	5	0.7	2.0	2.2	2.2	2.2	1.96
	(c.) " " " -	23	0.5	1.8	2.0	2.0	2.0	1.66
4	(a.) Settle Pond Pool, February 5th, 1894.	3	0.0	0.1	0.2	0.3	0.3	0.18
	(b.) " " " -	10	0.2	0.2	0.3	0.2	0.2	0.22
5	(a.) Mossley water, February 9th, 1894.	3	0.0	0.1	0.1	0.1	0.2	0.10
	(b.) " " " -	11	0.0	0.1	0.1	0.1	0.2	0.10
6	(a.) Settle Pond Pool, February 14th, 1894.	3	0.6	1.4	1.6	1.6	1.8	1.40
	(b.) " " " -	10	1.4	1.4	1.4	1.6	2.0	1.56
7	(a.) Mossley water, February 15th, 1894.	3	0.0	0.1	0.2	0.2	0.2	0.14
	(b.) " " " -	11	0.0	0.1	0.1	0.1	0.1	0.08
8	(a.) Mossley water, February 20th, 1894.	3	0.0	0.1	0.2	0.2	0.3	0.16
	(b.) " " " -	9	0.1	0.1	0.1	0.2	0.2	0.14
9	(a.) Shipley water, February 27th, 1894.	3	0.8	2.0	2.4	2.8	3.2	2.24
	(b.) " " " -	9	2.8	2.8	2.8	2.8	2.8	2.80
10	(a.) Mossley water, February 27th, 1894.	3	0.0	0.0	0.1	0.1	0.1	0.06
	(b.) " " " -	10	0.1	0.1	0.1	0.1	0.1	0.10

TABLE LXXXII.—*continued.*

Experiment.	Description of the Sample of Water.	Average rate of filtration (in minutes) per 50 c.c.	Action on Lead (Results expressed as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
11	(a.) Settle Pest Pool, March 2nd, 1894.	3	0·2	0·4	1·0	1·2	1·2	0·80
	(b.) " " " -	10	0·4	0·6	1·2	1·2	1·4	0·96
12	(a.) Shipley water, March 5th, 1894.	3	0·8	2·0	2·2	2·4	2·8	2·04
	(b.) " " " -	23	0·4	1·2	2·0	2·8	3·0	1·88
13	(a.) Settle Pest Pool, March 9th, 1894.	3	0·4	1·0	1·4	1·4	1·5	1·14
	(b.) " " " -	22	1·0	1·2	1·0	1·0	1·2	1·08
14	(a.) Shipley water, March 13th, 1894.	3	1·0	2·6	2·8	3·2	3·6	2·64
	(b.) " " " -	81	1·6	1·6	1·6	1·6	1·6	1·60
15	(a.) Mossley water, April 5th, 1894.	3	0·1	0·1	0·2	0·3	0·4	0·23
	(b.) " " " -	6	0·1	0·1	0·3	0·4	0·5	0·28
	(c.) " " " -	9	0·1	0·2	0·3	0·4	0·6	0·32
16	(a.) Shipley water, April 11th, 1894.	3	1·0	2·5	3·0	3·0	3·0	2·80
	(b.) " " " -	6	1·5	3·0	3·5	3·5	3·5	3·00
	(c.) " " " -	9	2·0	3·0	4·0	3·5	4·0	3·20
17	(a.) Mossley water, April 12th, 1894.	3	0·1	0·4	0·4	0·5	0·6	0·40
	(b.) " " " -	6	0·1	0·3	0·4	0·5	0·6	0·38
	(c.) " " " -	9	0·1	0·2	0·4	0·5	0·6	0·36
18	(a.) Shipley water, April 17th, 1894.	3	2·0	4·0	3·0	3·0	3·0	3·00
	(b.) " " " -	6	1·5	3·0	3·0	4·0	3·5	3·00
	(c.) " " " -	9	2·0	3·0	4·0	4·0	5·0	3·60
19	(a.) Mossley water, April 18th, 1894.	3	0·1	0·3	0·5	0·5	0·6	0·40
	(b.) " " " -	6	0·1	0·2	0·4	0·6	0·6	0·38
	(c.) " " " -	9	0·1	0·4	0·6	0·6	0·8	0·50
20	(a.) Shipley water, May 29th, 1894.	3	1·0	3·0	2·0	2·0	3·0	2·00
	(b.) " " " -	6	1·5	3·0	3·0	3·0	3·0	2·70
	(c.) " " " -	9	1·5	3·0	3·0	3·0	3·5	2·80
21	(a.) Mossley water, May 30th, 1894.	3	0·3	0·6	0·7	0·8	0·9	0·68
	(b.) " " " -	6	0·3	0·8	1·0	1·0	1·0	0·82
	(c.) " " " -	16	0·6	0·9	1·1	1·1	1·1	0·96
22	(a.) Shipley water, October 8th, 1894.	40 (secs.).	2·0	3·0	3·0	3·0	3·5	2·90
	(b.) " " " -	3 (min.).	2·0	3·0	3·5	3·5	4·0	3·20
23	(a.) Mossley Water, October 10th, 1894.	40 (secs.).	0·2	0·6	0·8	0·8	0·8	0·64
	(b.) " " " -	3 (min.).	0·1	0·4	0·7	0·8	1·0	0·60

The results were not always absolutely uniform in character, though they appear to indicate that slight variations in the rate of flow of the water through the lead shot would in no way affect the degree of plumbo-solvency. Further, that although a relatively slow rate of filtration was on the whole conducive to vigour of solvent action on lead, if the rate of filtration were further reduced, less dissolved lead appeared in the filtrate. Possibly, in these cases some of the lead passed out of solution and was retained in the shot. Lastly, Experiments 22 and 23 show that, even when the rate of filtration was very rapid (50 c.c. in 40 seconds), Shipley and Mossley waters were capable of dissolving lead in about the same proportion as when the rate of filtration was about 50 c.c. in 3 minutes. These experiments have a direct bearing on the passage of moorland waters through lead service pipes. They appear to indicate that, even if an acid moorland water were run rapidly through a lead service pipe some appreciable amount of lead might be taken up by the water, and that the question of the length of time the water was in contact with the lead is, as regards plumbo-solvency, possibly of less importance than in relation to erosion.

In the following table (Table LXXXIII.) the effect, as regards plumbo-solvency, of passing an acid water repeatedly through lead shot is shown :—

TABLE LXXXIII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of passing an ACID WATER repeatedly through LEAD SHOT.

No. of Experiment.	Description of the Experiment.	Action on Lead. (Results stated as Parts per 100,000.)
1	September 10th, 1894.—600 c.c. Shipley water filtered through 50 c.c. washed lead shot (upward filtration) at rate of 3 mins. per 50 c.c. The water was filtered through same lead shot three times, and 10 c.c. was removed each time for estimation of lead. (a.) After 1st filtration (b.) " 2nd " (c.) " 3rd "	(a.) 3.0 (b.) 3.0 (c.) 3.0
2	April 5th, 1895.—700 c.c. Shipley water filtered through 50 c.c. washed lead shot (upward filtration) at rate of 3 mins. per 50 c.c. The water was filtered through same lead shot four times, and 10 c.c. was removed each time for estimation of lead. (a.) After 1st filtration (b.) " 2nd " (c.) " 3rd " (d.) " 4th "	(a.) 2.0 (b.) 2.0 (c.) 2.0 (d.) 2.0
3	April 18th, 1895.—700 c.c. Shipley water filtered through 50 c.c. washed lead shot (upward filtration) at rate of 3 mins. per 50 c.c. The water was filtered through same lead shot five times, and 10 c.c. removed each time for estimation of lead. (a.) After 1st filtration (b.) " 2nd " (c.) " 3rd " (d.) " 4th " (e.) " 5th "	(a.) 2.0 (b.) 2.0 (c.) 2.0 (d.) 2.0 (e.) 2.5
4	April 24th, 1895.—700 c.c. Shipley water filtered through 50 c.c. washed lead shot (upward filtration) at rate of 3 mins. per 50 c.c. The water was filtered through same lead shot five times, and 10 c.c. removed each time for estimation of lead. (a.) After 1st filtration (b.) " 2nd " (c.) " 3rd " (d.) " 4th " (e.) " 5th "	(a.) 2.0 (b.) 2.0 (c.) 2.0 (d.) 2.0 (e.) 2.0

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TABLE LXXXIII.—*continued.*

No. of Experiment.	Description of the Experiment.	Action on Lead. (Results stated as Parts per 100,000.)
5	<p>November 18th, 1895.—700 c.c. Shipley water filtered through 50 c.c. washed lead shot (upward filtration) at rate of 3 mins. per 50 c.c. The water was filtered through same lead shot four times, and 20 c.c. removed each time.</p> <p>(a.) After 1st filtration - - - - -</p> <p>(b.) " 2nd "</p> <p>(c.) " 3rd "</p> <p>(d.) " 4th "</p> <p>10 c.c. was used for estimation of lead, and 10 c.c. for reaction with laccmoid.</p> <p>It was found that after the 1st, 2nd, 3rd, and 4th filtrations the water still gave a faintly acid reaction, the amount being apparently the same in each case.</p>	<p>(a.) 2·5</p> <p>(b.) 3·0</p> <p>(c.) 3·0</p> <p>(d.) 3·0</p>

It will be seen that the repeated passage of the same water through the same lead shot did not usually result in the water-dissolving relatively more lead on the last than on the first occasion.

The effect, as regards plumbo-solvency, of boiling certain acid moorland waters, and then making up with neutral distilled water to the original bulk, is shown in the following table (Table LXXXIV.) :—

TABLE LXXXIV.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of BOILING certain ACID MOORLAND WATERS.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) Shipley water, June 4, 1894 - - -	3·0	4·0	4·0	4·0	5·0	4·00
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	1·5	4·0	3·5	4·0	3·5	3·30
2	(a.) Shipley water, June 18, 1894 - - -	1·5	3·0	3·3	4·0	4·0	3·18
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	1·0	2·5	2·5	3·0	3·0	2·40
3	(a.) Mossley water, June 10, 1894 - - -	0·3	0·6	0·8	0·9	0·9	0·70
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0·0	0·1	0·1	0·1	0·2	0·10

TABLE LXXXIV.—*continued.*

Experiment.	Description of the Experiment.	Action on Lead (Result stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
4	(a.) Shipley water, June 25, 1894 - -	2.0	3.0	3.0	3.5	3.0	2.90
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	1.0	2.5	2.5	3.0	3.0	2.40
5	(a.) Mossley water, June 27, 1894 - -	0.2	0.5	0.6	0.7	0.8	0.56
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0.1	0.3	0.4	0.5	0.6	0.36
6	(a.) Shipley water, July 3, 1894 - -	2.0	3.0	3.0	3.0	3.0	2.90
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0.5	2.0	2.0	2.0	2.0	1.70
7	(a.) Mossley water, July 4, 1894 - -	0.2	0.5	0.6	0.7	0.8	0.56
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0.0	0.0	0.0	0.0	0.0	0.00
8	(a.) Shipley water, July 16, 1894 - -	1.5	2.5	3.0	3.0	3.0	2.60
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0.5	2.0	2.0	2.0	2.0	1.70
9	(a.) Shipley water, July 23, 1894 - -	1.0	2.0	3.0	3.5	4.0	2.70
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0.5	2.0	2.5	3.0	3.0	2.20
10	(a.) Mossley water, July 24, 1894 - -	0.0	0.3	0.5	0.6	0.7	0.42
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0.0	0.2	0.3	0.4	0.5	0.28
11	(a.) Mossley water, August 28, 1894 - -	0.2	0.4	0.7	0.8	0.8	0.58
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	0.1	0.1	0.1	0.2	0.2	0.14
12	(a.) Shipley water, September 3, 1894 - -	1.0	3.0	3.0	4.0	3.0	2.90
	(b.) The same water after boiling for $\frac{1}{2}$ hour and making up to original mark with neutral distilled water.	1.0	2.0	2.5	2.5	2.5	2.10

The results show that although boiling and then making up with neutral distilled water to the original bulk reduced the degree of plumbo-solvency of Shipley water, the water was still left in a dangerous condition as regards its solvent action on lead. Somewhat similar results were obtained with Mossley water, although here boiling reduced the original plumbo-solvent ability of the water to a greater extent.

In the following table (LXXXV.) the effect, as regards plumbosolvency, of the aeration of certain acid moorland waters is shown:—

TABLE LXXXV.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the AERATION of certain ACID MOORLAND WATERS.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at the rate of 3 minutes per 50 c.c.]

Experiments.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) February 8, 1894, Settle Peat Pool water.	0.36	0.1	0.2	0.4	0.5	0.6	0.36
	(b.) The same water after air had been aspirated through it for $\frac{1}{2}$ hour.	—	0.1	0.2	0.6	0.6	0.7	0.44
2	(a.) March 20, 1894, Shipley water.	0.90	0.6	1.2	1.6	1.8	2.0	1.44
	(b.) The same water after air had been aspirated through it for 2 hours.	—	0.4	1.2	1.8	1.8	2.0	1.44
3	(a.) August 21, 1894, Shipley water.	1.30	2.0	4.0	4.0	5.0	5.0	4.00
	(b.) The same water after air had been aspirated through it for $\frac{1}{2}$ hour.	—	1.5	4.0	4.5	4.5	4.5	3.80
4	(a.) August 21, 1894, Mossley water.	0.42	0.1	0.3	0.4	0.7	0.8	0.46
	(b.) The same water after air had been aspirated through it for $\frac{1}{2}$ hour.	—	0.1	0.3	0.4	0.7	0.8	0.46
5	(a.) September 10, 1894, Shipley water.	0.96	1.0	2.0	2.0	2.5	2.5	2.00
	(b.) The same water after air had been aspirated through it for 1 hour.	0.90	1.0	2.0	2.5	2.5	2.5	2.10
6	(a.) September 11, 1894, Mossley water.	0.42	0.2	0.5	0.6	0.8	0.8	0.58
	(b.) The same water after air had been aspirated through it for 1 hour.	0.33	0.0	0.2	0.4	0.6	0.7	0.38
7	(a.) December 17, 1894, Shipley water.	1.20	2.5	3.0	3.5	3.5	4.0	3.30
	(b.) The same water after air had been aspirated through it for $\frac{1}{2}$ hour.	1.20	2.5	3.0	3.5	3.5	4.0	3.30
8	(a.) December 18, 1894, Mossley water.	0.36	0.2	0.4	0.6	0.8	0.8	0.56
	(b.) The same water after air passed through for $\frac{1}{2}$ hour.	0.36	0.2	0.4	0.6	0.7	0.8	0.54
9	(a.) January 29, 1895, Shipley water.	0.96	1.0	2.5	2.5	2.5	2.5	2.20
	(b.) The same water after air had been aspirated through it for $\frac{1}{2}$ hour.	0.90	1.0	2.0	2.0	2.0	2.5	1.90
10	(a.) July 2nd, 1895, Shipley water	0.72	1.0	1.0	1.5	2.0	2.0	1.50
	(b.) The same water after air had been aspirated through for 3 hours.	0.72	0.8	1.6	1.6	1.6	1.8	1.48
11	(a.) July 9, 1895, Shipley water	0.78	1.5	1.5	1.5	2.0	2.0	1.70
	(b.) The same water after air had been aspirated through for 3 hours.	0.72	0.5	1.0	1.5	2.0	2.0	1.40

It will be noted that aeration did not materially influence the acidity or plumbo-solvent ability of the acid moorland waters. To a slight, but scarcely appreciable, extent, aeration may be said to have had usually a tendency to reduce the acidity and plumbo-solvent ability.

The effect, as regards plumbo-solvency, of the concentration by boiling of Shipley water is shown in the following table (Table LXXXVI.) :—

TABLE LXXXVI.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the CONCENTRATION by boiling of SHIPLEY WATER.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) February 5th, 1895. Shipley water.	0.96	1.0	2.5	3.0	3.0	3.0	2.50
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	0.90	2.0	3.0	3.0	3.0	3.0	2.80
2	(a.) February 12th, 1895. Shipley water.	0.78	1.0	1.5	1.5	2.0	2.0	1.60
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.26	2.5	4.0	4.0	4.0	4.0	3.70
3	(a.) February 17th, 1895. Shipley water.	0.54	0.5	1.0	1.0	1.5	1.5	1.10
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	0.73	1.0	2.5	3.0	3.0	3.0	2.50
4	(a.) February 25th, 1895. Shipley water.	0.96	1.5	2.0	2.0	2.0	2.0	1.90
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.74	4.0	7.0	7.0	7.0	7.0	6.40
5	(a.) March 5th, 1895. Shipley water.	0.84	2.0	2.5	2.5	3.0	3.0	2.60
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.68	2.0	3.0	4.0	4.0	4.0	3.40
6	(a.) March 12th, 1895. Shipley water.	0.90	1.5	2.0	2.0	2.0	2.0	1.90
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.44	1.5	4.0	4.0	5.0	5.0	3.90
7	(a.) March 19th, 1895. Shipley water.	0.90	1.5	1.5	2.0	2.0	2.0	1.80
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.44	3.0	4.5	5.0	5.0	5.0	4.50



TABLE LXXXVI.—*continued.*

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
8	(a.) March 26th, 1895. Shipley water.	0.81	1.5	2.0	2.0	2.0	2.5	2.00
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.44	4.0	5.0	5.0	5.0	5.0	4.80
9	(a.) April 2nd, 1895. Shipley water.	0.98	2.0	2.5	3.0	3.0	3.0	2.70
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.65	4.0	5.0	5.0	5.5	5.5	5.00
10	(a.) April 9th, 1895. Shipley water.	0.84	1.5	2.0	2.0	2.5	2.5	2.10
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.56	3.0	4.0	5.0	5.0	5.0	4.40
11	(a.) April 16th, 1895. Shipley water.	0.72	0.5	1.0	1.5	1.5	1.5	1.20
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.20	2.0	3.0	3.5	3.5	3.5	3.10
12	(a.) April 23rd, 1895. Shipley water.	0.78	1.0	1.5	2.0	2.0	2.0	1.70
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.44	2.0	4.0	4.0	4.0	4.0	3.60
13	(a.) April 30th, 1895. Shipley water.	0.96	1.5	2.5	2.5	2.5	2.0	2.20
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.92	3.0	4.0	5.0	5.0	4.5	4.30
14	(a.) May 7th, 1895. Shipley water.	0.78	1.0	1.0	1.5	1.5	2.0	1.40
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.56	2.5	3.5	4.0	4.0	4.0	3.60
15	(a.) May 14th, 1895. Shipley water.	0.78	1.0	2.0	2.0	2.0	2.0	1.80
	(b.) The same water after evaporation by boiling to $\frac{1}{2}$ original volume.	1.56	3.0	4.0	4.0	4.0	4.0	3.80

It will be seen that boiling Shipley water down to half its original bulk usually led to an increase in its acidity and plumbo-solvent ability, roughly corresponding with the degree of concentration. These results do not lend support to the silica theory.

In the following table (Table LXXXVII.) the effect, as regards plumbo-solvency, of the addition to certain acid waters of lead which had previously been submitted to the action of sodium carbonate and calcium sulphate is shown :—

TABLE LXXXVII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to certain ACID WATERS of LEAD which had previously been submitted to the action of SODIUM CARBONATE and CALCIUM SULPHATE.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a) Distilled water X (natural acidity) -	0.2	0.4	0.6	0.6	0.6	0.46
	(b) Same as (a), but the lead left in contact with $\frac{2}{10}$ Na <sub>2</sub> CO <sub>3</sub> for 18 hours, and then washed.	0.1	0.3	0.4	0.5	0.6	0.38
2	(a) Shipley water, September 3rd, 1894 -	1.0	3.0	3.0	4.0	3.0	2.80
	(b) Same as (a), but the lead left in contact with saturated solution Na <sub>2</sub> CO <sub>3</sub> for three days, and then washed.	0.0	0.5	1.0	1.0	1.5	0.80
	(c) Same as (a), but the lead left in contact with saturated solution CaSO <sub>4</sub> for three days, and then washed.	1.0	2.5	2.5	2.5	3.0	2.30

The results seem to show that a preliminary "treatment" of lead with a solution of calcium sulphate has but little power of protecting such lead from the action of a plumbo-solvent water. Sodium carbonate appeared to be more efficacious in this respect.

The following ten tables show the effect, as regards plumbo-solvency, of the addition to acid moorland waters of a measured quantity of each of the following substances :—magnesium sulphate, calcium sulphate, sodium chloride, ammonium chloride, potassium nitrate, ammonium nitrate, sodium nitrate, sodium nitrite, calcium phosphate and sodium phosphate, and potassium silicate.

TABLE LXXXVIII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to different ACID WATERS of MEASURED QUANTITIES of MAGNESIUM SULPHATE ( $\text{MgSO}_4$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Settle Peat Pool, February 5th, 1894 -	0·0	0·1	0·2	0·3	0·3	0·18
	The same water, + 0·1 per cent. $\text{MgSO}_4$ -	0·0	0·2	0·4	0·4	0·5	0·30
2	Mossley water, February 16th, 1894 -	0·0	0·1	0·2	0·2	0·2	0·14
	The same water, + 0·1 per cent. $\text{MgSO}_4$ -	0·0	0·1	0·1	0·1	0·1	0·08
3	Mossley water, March 10th, 1894 -	0·1	0·1	0·2	0·4	0·4	0·24
	The same water, + 0·1 per cent. $\text{MgSO}_4$ -	0·1	0·1	0·2	0·3	0·4	0·22
4	Shipley water, March 13th, 1894 -	1·0	2·6	2·8	3·2	3·6	2·64
	The same water, + 0·1 per cent. $\text{MgSO}_4$ -	0·8	1·0	2·0	2·2	2·4	1·68
5	Shipley water, December 10th, 1894 -	1·0	2·0	2·5	2·5	2·5	2·10
	The same water, + 0·1 per cent. $\text{MgSO}_4$ -	1·0	2·0	3·0	2·5	3·0	2·30
6	Mossley water, December 11th, 1894 -	0·0	0·1	0·1	0·2	0·2	0·12
	The same water, + 0·1 per cent. $\text{MgSO}_4$ -	0·0	0·1	0·2	0·3	0·3	0·18
7	Mossley water, January 16th, 1895 -	0·0	0·1	0·1	0·1	0·2	0·10
	The same water, + 0·1 per cent. $\text{MgSO}_4$ -	0·1	0·1	0·1	0·1	0·2	0·12

The results varied considerably ; but on the whole they seem to indicate that the magnesium sulphate does not influence, to any material extent, the plumbo-solvent action of the water.

TABLE LXXXIX.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of CALCIUM SULPHATE ( $\text{CaSO}_4$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed shot filtered at the uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results expressed as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Settle Peat Pool, January 25th, 1894 -	0.1	0.3	0.5	0.5	0.5	0.38
	The same water, shaken with excess $\text{CaSO}_4$ , decanted.	0.1	0.3	0.4	0.5	0.6	0.38
2	Distilled water acidified with HCl -	0.4	0.8	0.8	0.8	0.8	0.72
	The same water left in contact with excess $\text{CaSO}_4$ for 12 hours, decanted.	0.4	0.8	1.0	1.0	1.0	0.84
3	Distilled water X acid reaction -	0.1	0.3	0.4	0.5	0.4	0.34
	The same water shaken with excess $\text{CaSO}_4$ , decanted.	0.0	0.1	0.4	0.4	0.5	0.28
4	Mossley water, March 10th, 1894 -	0.1	0.1	0.2	0.4	0.4	0.24
	The same water shaken with excess $\text{CaSO}_4$ for $\frac{1}{2}$ hour and filtered.	0.0	0.0	0.0	0.0	0.1	0.02
5	Shipley water, March 13th, 1894 -	1.0	2.6	2.8	3.2	3.6	2.64
	The same water shaken with excess $\text{CaSO}_4$ for $\frac{1}{2}$ hour and filtered.	0.8	1.6	2.2	2.8	2.8	2.04
6	Shipley water, March 20th, 1894 -	0.6	1.2	1.6	1.8	2.0	1.44
	The same water shaken with excess $\text{CaSO}_4$ for $\frac{1}{2}$ hour and filtered.	0.4	1.2	1.8	1.8	1.8	1.40
7	Shipley water, July 23rd, 1894 -	1.0	2.0	3.0	3.5	4.0	2.70
	The same water shaken with excess $\text{CaSO}_4$ for $\frac{1}{2}$ hour and decanted.	0.5	1.5	1.5	1.5	2.0	1.40
8	Shipley water, August 27th, 1894 -	1.0	3.0	3.0	3.0	3.0	2.80
	The same water left overnight in contact with excess $\text{CaSO}_4$ and decanted.	1.5	3.0	3.0	3.0	3.0	2.70
9	Mossley water, August 28th, 1894 -	0.2	0.4	0.7	0.8	0.8	0.58
	The same water left overnight in contact with excess $\text{CaSO}_4$ and decanted.	0.1	0.4	0.6	0.8	0.8	0.54
10	Shipley water, November 26th, 1894 -	0.5	1.5	2.0	2.5	2.0	1.70
	The same water left overnight in contact with excess $\text{CaSO}_4$ and decanted.	1.0	2.5	2.5	3.0	3.0	2.40

It will be noted that calcium sulphate added in excess to moorland waters does not materially influence their plumbo solvent ability.

TABLE XC.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of SODIUM CHLORIDE (NaCl).

[The action on lead was tested by upward filtration through 50 c.c. washed shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results expressed as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Distilled water X acid reaction - -	0.1	0.3	0.4	0.5	0.4	0.34
	The same water, + 0.1 per cent. sodium chloride.	0.0	0.1	0.3	0.4	0.6	0.28
2	Settle Peat Pool, February 14th, 1894 -	0.6	1.4	1.6	1.6	1.8	1.40
	The same water, + 0.1 per cent. NaCl -	0.6	0.8	1.0	1.0	1.0	0.88
3	Mossley water, February 16th, 1894 -	0.0	0.1	0.2	0.2	0.2	0.14
	The same water, + 0.1 per cent. NaCl -	0.1	0.1	0.1	0.2	0.2	0.14
4	Mossley water, February 20th, 1894 -	0.0	0.1	0.2	0.2	0.3	0.16
	The same water, + 0.1 per cent. NaCl -	0.0	0.1	0.3	0.2	0.3	0.16
5	Shipley water, February 27th, 1894 -	0.8	2.0	2.4	2.8	3.2	2.24
	The same water, + 0.1 per cent. NaCl -	0.6	2.0	2.0	2.4	2.4	1.88
6	Shipley water, December 3rd, 1894 -	1.5	2.0	2.5	2.5	2.5	2.30
	The same water, + 0.1 per cent. NaCl -	1.0	2.0	2.5	2.5	2.0	2.00
7	Mossley water, December 4th, 1894 -	0.1	0.1	0.2	0.2	0.4	0.20
	The same water, + 0.1 per cent. NaCl -	0.1	0.1	0.4	0.2	0.2	0.20

TABLE XCI.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of AMMONIUM CHLORIDE ( $\text{NH}_4\text{Cl}$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Mossley water, March 22nd, 1894 - -	0·0	0·1	0·2	0·2	0·4	0·18
	The same water, + 0·1 per cent. ammonium chloride.	0·1	0·2	0·3	0·4	0·6	0·32
2	Shipley water, April 3rd, 1894 - - -	2·0	2·5	3·0	3·0	3·0	2·70
	The same water, + 0·1 per cent. $\text{NH}_4\text{Cl}$ -	1·5	2·5	3·0	3·0	3·0	2·60
3	Mossley water, June 6th, 1894 - - -	0·2	0·6	0·8	0·9	0·9	0·68
	The same water, + 0·1 per cent. $\text{NH}_4\text{Cl}$ -	0·3	0·7	0·8	0·8	0·9	0·70
4	Shipley water, June 18th, 1894 - - -	1·5	3·0	3·3	4·0	4·0	3·16
	The same water, 0·1 per cent. $\text{NH}_4\text{Cl}$ -	1·0	2·5	2·5	2·5	3·0	2·50
5	Mossley water, June 19th, 1894 - - -	0·3	0·6	0·8	0·9	0·9	0·70
	The same water, + 0·1 per cent. $\text{NH}_4\text{Cl}$ -	0·3	0·6	0·7	0·8	0·9	0·64
6	Mossley water, September 4th, 1894 - -	0·1	0·3	0·6	0·7	0·8	0·50
	The same water, + 0·5 per cent. $\text{NH}_4\text{Cl}$ -	0·6	1·0	1·2	1·2	1·6	1·12
7	Shipley water, January 21st, 1895 - - -	1·0	2·5	2·5	3·0	3·0	2·40
	The same water, + 0·1 per cent. $\text{NH}_4\text{Cl}$ -	1·0	2·5	3·0	3·0	3·0	2·50
8	Dunford Bridge Reservoir, January 23rd, 1895.	0·1	0·3	0·4	0·5	0·5	0·36
	The same water, + 0·1 per cent. $\text{NH}_4\text{Cl}$ -	0·3	0·5	0·6	0·6	0·7	0·54
9	Higher Swineshaw Reservoir, January 31st, 1895.	0·2	1·0	1·2	1·2	1·2	0·96
	The same water, + 0·1 per cent. $\text{NH}_4\text{Cl}$ -	0·4	0·8	1·0	1·0	1·2	0·88

It will be seen from the above tables that the chlorides of sodium and ammonium respectively do not appear to influence materially the plumbo-solvent power of a moorland water.

TABLE XCII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of POTASSIUM NITRATE ( $\text{KNO}_3$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Shipley water, March 20th, 1894 - -	0.6	1.2	1.6	1.8	2.0	1.44
	The same water, + 0.1 per cent. potassium nitrate.	0.4	1.4	1.6	2.0	2.2	1.52
2	Mossley water, March 22nd, 1894 - -	0.0	0.1	0.2	0.2	0.4	0.18
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	0.0	0.1	0.3	0.3	0.4	0.22
3	Mossley water, March 31st, 1894 - -	0.0	0.1	0.2	0.3	0.4	0.20
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	0.0	0.1	0.3	0.3	0.5	0.29
4	Shipley water, April 3rd, 1894 - -	2.0	2.5	3.0	3.0	3.0	2.70
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	2.0	3.0	3.0	3.0	3.0	2.80
5	Shipley water, October 23rd, 1894 - -	3.0	4.0	4.0	4.0	4.0	3.80
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	2.5	4.0	4.0	4.0	4.0	3.70
6	Mossley water, October 23rd, 1894 - -	0.1	0.4	0.6	0.8	0.8	0.54
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	0.2	0.5	0.8	1.0	1.0	0.70
7	Watersheddel's Reservoir, November 17th, 1894.	0.2	1.6	2.0	2.4	2.4	1.72
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	0.5	2.0	2.4	2.4	2.4	1.94
8	Shipley water, November 19th, 1894 - -	1.5	3.0	2.5	3.0	3.0	2.60
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	2.0	3.0	3.0	3.0	3.0	2.80
9	Mossley water, November 30th, 1894 - -	0.1	0.2	0.3	0.4	0.4	0.23
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	0.1	0.3	0.4	0.5	0.6	0.33
10	Shipley water, November 26th, 1894 - -	0.5	1.5	2.0	2.5	2.0	1.70
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	1.0	2.0	2.5	2.5	3.0	2.2
11	Mossley water, November 27th, 1894 - -	0.1	0.4	0.4	0.4	0.5	0.36
	The same water, + 0.1 per cent. $\text{KNO}_3$ -	0.2	0.4	0.5	0.5	0.6	0.44

TABLE XCIII

Showing the Effect, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of AMMONIUM NITRATE ( $\text{NH}_4\text{NO}_3$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Mossley water, April 5th, 1894	0.1	0.1	0.2	0.3	0.4	0.22
	The same water, + 0.1 per cent. ammonium nitrate.	0.2	0.6	0.6	0.8	0.8	0.60
2	Shipley water, April 11th, 1894	1.0	2.5	3.0	3.0	3.0	2.50
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	2.0	3.0	4.0	3.5	4.0	3.30
3	Mossley water, April 12th, 1894	0.1	0.4	0.4	0.5	0.6	0.40
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	0.1	0.5	0.6	0.6	0.8	0.52
4	Shipley water, June 4th, 1894	3.0	4.0	4.0	4.0	5.0	4.00
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	2.5	3.0	3.5	4.0	4.0	3.40
5	Shipley water, August 21st, 1894	2.0	4.0	4.0	5.0	5.0	4.00
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	2.0	4.0	4.5	5.0	5.0	4.10
6	Mossley water, August 21st, 1894	0.1	0.3	0.4	0.7	0.8	0.46
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	0.2	0.6	0.8	1.0	1.2	0.76
7	Shipley water, August 27th, 1894	1.0	3.0	3.0	3.0	3.0	2.60
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	1.5	2.5	3.0	3.0	3.0	2.60
8	Mossley water, August 28th, 1894	0.2	0.4	0.7	0.8	0.8	0.58
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	0.2	0.7	1.0	1.0	1.2	0.82
9	Shipley water, September 3rd, 1894	1.0	3.0	3.0	4.0	3.0	2.80
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	1.5	3.0	3.5	3.5	3.5	3.00
10	Mossley water, September 4th, 1894	0.1	0.3	0.6	0.7	0.8	0.50
	The same water, + 0.5 per cent. $\text{NH}_4\text{NO}_3$	0.7	1.2	1.6	1.6	1.6	1.34
11	Mossley water, October 10th, 1894	0.1	0.4	0.7	0.8	1.0	0.60
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	0.4	1.0	1.2	1.4	1.6	1.1
12	Mossley water, November 13th 1894	0.0	0.1	0.3	0.5	0.6	0.30
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	0.6	0.8	1.0	1.1	1.2	0.94
13	Mossley water, November 20th, 1894	0.1	0.2	0.3	0.4	0.4	0.28
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	0.2	0.4	0.6	0.7	0.8	0.54
14	Mossley water, January 16th, 1895	0.0	0.1	0.1	0.1	0.2	0.10
	The same water, + 0.1 per cent. $\text{NH}_4\text{NO}_3$	0.3	0.3	0.4	0.4	0.5	0.36



TABLE XCIV.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of SODIUM NITRATE ( $\text{NaNO}_3$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Mossley water, April 5th, 1894 - -	0·1	0·1	0·2	0·3	0·4	0·22
	The same water, + 0·1 per cent. sodium nitrate.	0·2	0·5	0·5	0·6	0·8	0·48
2	Mossley water, June 6th, 1894 - -	0·2	0·6	0·8	0·9	0·9	0·68
	The same water, + 0·1 per cent. $\text{NaNO}_3$	0·3	0·7	0·8	0·8	0·8	0·68
3	Mossley water, August 28th, 1894 - -	0·2	0·4	0·7	0·8	0·8	0·58
	The same water, + 0·1 per cent. $\text{NaNO}_3$ -	0·2	0·4	0·7	0·8	1·0	0·62
4	Shipley water, October 30th, 1894 - -	1·0	3·0	3·0	4·0	4·0	3·00
	The same water, + 0·1 per cent. $\text{NaNO}_3$ -	1·0	3·0	3·0	4·0	4·0	3·00
5	Mossley water, October 30th, 1894 - -	0·0	0·1	0·2	0·4	0·5	0·24
	The same water, + 0·1 per cent. $\text{NaNO}_3$ -	0·1	0·3	0·4	0·5	0·6	0·38
6	Shipley water, November 5th, 1894 - -	2·0	2·5	3·5	3·0	3·0	2·80
	The same water, 0·1 per cent. $\text{NaNO}_3$ -	2·0	2·5	3·5	3·0	3·0	2·80
7	Mossley water, November 6th, 1894 -	0·1	0·4	0·5	0·6	0·6	0·44
	The same water + 0·1 per cent $\text{NaNO}_3$ -	0·2	0·5	0·5	0·6	0·8	0·52
8	Shipley water, November 13th, 1894 - -	2·0	3·0	3·5	4·0	4·0	3·30
	The same water, + 0·1 per cent. $\text{NaNO}_3$ -	2·0	3·5	4·0	4·0	4·0	3·50
9	Mossley water, November 13th, 1894 -	0·0	0·1	0·3	0·5	0·6	0·30
	The same water, + 0·1 per cent. $\text{NaNO}_3$ -	0·1	0·4	0·5	0·7	0·7	0·48
10	Dunford Reservoir, November 24th, 1894 -	0·1	0·4	0·5	0·6	0·6	0·44
	The same water, + 0·1 per cent. $\text{NaNO}_3$ -	0·1	0·5	0·7	0·8	0·8	0·58

The above results seem to show that although potassium nitrate, ammonium nitrate, and sodium nitrate do not influence the plumbo-solvent ability of moorland waters to any great extent, yet, on the whole, they appear to have a tendency to increase the solvent action of the water on lead.

TABLE XCV.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to certain ACID MOORLAND WATERS of MEASURED QUANTITIES of SODIUM NITRITE ( $\text{NaNO}_2$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed shot at the rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results expressed as Parts per 100,000).						% Reduction.
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	Settle Peat Pool, February 5th, 1894.	0.0	0.1	0.2	0.3	0.3	0.18	100 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.0	0.0	0.0	0.0	0.0	0.00	
2	Settle Peat Pool, February 8th, 1894.	0.1	0.2	0.4	0.5	0.6	0.36	89 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.0	0.0	0.0	0.1	0.1	0.04	
	Mossley water, February 9th, 1894.	0.0	0.0	0.1	0.1	0.2	0.08	100 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.0	0.0	0.0	0.0	0.0	0.00	
4	Mossley water, February 16th, 1894.	0.0	0.1	0.2	0.2	0.2	0.14	100 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.0	0.0	0.0	0.0	0.0	0.00	
5	Mossley water, February 20th, 1894.	0.0	0.1	0.2	0.2	0.3	0.16	100 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.0	0.0	0.0	0.0	0.0	0.00	
6	Settle Peat Pool, February 24th, 1894.	0.4	1.0	1.2	1.2	1.2	1.00	78 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.0	0.2	0.3	0.3	0.3	0.22	
7	Shipley water, February 27th, 1894.	0.8	2.0	2.4	2.8	3.2	2.24	25 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.8	1.6	2.0	2.0	2.0	1.68	
8	Settle Peat Pool, February 28th, 1894.	0.4	0.9	1.0	1.2	1.2	0.94	79 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.2	0.2	0.2	0.2	0.2	0.20	
9	Shipley water, March 5th, 1894.	0.8	2.0	2.2	2.4	2.8	2.04	49 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.2	1.0	1.2	1.2	1.6	1.04	
10	Settle Peat Pool, March 9th, 1894.	0.4	1.0	1.4	1.4	1.5	1.14	68 per cent.
	The same water + 0.1 per cent. sodium nitrite.*	0.1	0.2	0.4	0.5	0.6	0.36	

\* The sample of sodium nitrite had an alkaline reaction. Probably the reduction of the plumbo-solvent ability after the addition of the salt was due, at all events in part, to this cause.

Sodium nitrite seemed to have a decidedly inhibitory influence on the plumbo-solvent power of moorland waters; but it was found out after the experiments were completed that the sample of sodium nitrite

employed had an alkaline reaction; this fact probably explains the apparent inhibition of plumbo-solvency.

TABLE XCVI.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to certain ACID MOORLAND WATERS of MEASURED QUANTITIES of—(a) CALCIUM PHOSPHATE and (b) SODIUM PHOSPHATE.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) April 5, 1894, Moosley water	0.30	0.1	0.1	0.2	0.3	0.4	0.22
	(b.) The same water + 0.1 per cent. calcium phosphate.	Neutral	0.0	0.0	0.0	0.1	0.1	0.04
2	(a.) June 4, 1894, Shipley water -	1.30	3.0	4.0	4.0	4.0	5.0	4.00
	(b.) The same water + 0.1 per cent. sodium phosphate.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
3	(a.) December 10, 1894, Shipley water after filtration through filter-paper.	Acid	0.5	0.5	0.5	1.0	1.0	0.70
	(b.) The same water shaken with 0.1 per cent. sodium phosphate and filtered through filter-paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) The same water shaken with 0.1 per cent. calcium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
4	(a.) December 17, 1894, Shipley water after filtration through filter paper.	Acid	1.0	2.0	2.5	3.0	3.0	2.30
	(b.) The same water shaken with 0.1 per cent. sodium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) The same water shaken with 0.1 per cent. calcium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
5	(a.) March 19, 1895, Shipley water after filtration through filter paper.	0.48	0.4	0.8	1.0	1.0	1.0	0.84
	(b.) The same water shaken with 0.1 per cent. sodium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) The same water shaken with 0.1 per cent. calcium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
6	(a.) March 26, 1895, Shipley water after filtration through filter paper.	0.60	0.8	1.4	1.6	1.6	1.6	1.40
	(b.) The same water shaken with 0.1 per cent. sodium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) The same water shaken with 0.1 per cent. calcium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE XCVI.—*continued.*

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
7	(a.) April 2, 1895, Shipley water after filtration through filter paper.	0.72	1.2	1.4	1.6	1.6	1.6	1.48
	(b.) The same water shaken with 0.1 per cent. sodium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) The same water shaken with 0.1 per cent. calcium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
8	(a.) April 9, 1895, Shipley water after filtration through filter paper.	0.72	0.8	1.4	1.6	1.6	1.8	1.44
	(b.) The same water shaken with 0.1 per cent. sodium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) The same water shaken with 0.1 per cent. calcium phosphate and filtered through filter paper.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

Both calcium and sodium phosphates, used in the proportion of 0.1 per cent., removed from acid moorland waters their plumbo-solvent ability; but in each case treatment with these substances neutralised the acidity of the waters, and this would in all probability account for the results.

TABLE XCVII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of POTASSIUM SILICATE.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot, at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Mossley water, March 10th, 1894 - -	0.1	0.1	0.2	0.4	0.4	0.24
	The same water, shaken with excess potassium silicate, and filtered.	*0.0	0.0	0.0	0.0	0.0	0.00
2	Shipley water, March 13th, 1894 - -	1.0	2.6	2.8	3.2	3.6	2.64
	The same water, shaken with excess potassium silicate, and decanted.	*0.0	0.0	0.0	0.0	0.0	0.00
3	Shipley water, March 27th, 1894 - -	0.8	2.4	2.8	3.2	3.2	2.48
	The same water, shaken with excess potassium silicate, and filtered.	*0.0	0.0	0.0	0.0	0.0	0.00

\* The sample of potassium silicate had a marked alkaline reaction, and its addition to the water in each case removed the acidity. There can be little doubt that the absence of the plumbo-solvent ability after the addition of the salt was due to this cause.

There can be little doubt that in the case of potassium silicate also the inhibition of plumbo-solvency was due, not to the action of the silicate, as silicate, but to the presence of alkali neutralising the acidity of the water, and therefore correcting its plumbo-solvent ability.

In the following table (Table XCVIII.) the effect, as regards plumbo-solvency, of the addition to various acid waters of measured quantities of silica ( $\text{SiO}_2$ ) is shown :—

TABLE XCVIII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of SILICA ( $\text{SiO}_2$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per c.c.]

Experiment.	Description of the Sample of Water.	Acidity in terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the water.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) Shipley water, October 30th, 1894.	1.00	1.0	3.0	3.0	4.0	4.0	3.00
	(b.) The same water after shaking with excess silica ( $\text{SiO}_2$ ); allowed to stand for 12 hours, and then decanted.	0.78	1.0	2.0	2.5	2.5	2.5	2.10
2	(a.) Mossley water, October 30th, 1894.	0.36	0.0	0.1	0.2	0.4	0.5	0.24
	(b.) The same water after shaking with excess silica ( $\text{SiO}_2$ ); allowed to stand for 12 hours, and then decanted.	0.24	0.1	0.1	0.2	0.2	0.3	0.18
3	(a.) Shipley water, November 5th, 1894.	1.02	2.0	2.5	3.5	3.0	3.0	2.8
	(b.) The same water after shaking with excess silica ( $\text{SiO}_2$ ); allowed to stand for 12 hours, and then decanted.	0.78	1.0	1.5	2.0	2.5	2.5	1.90
4	(a.) Mossley water, November 5th, 1894.	0.42	0.1	0.4	0.5	0.6	0.6	0.44
	(b.) The same water after shaking with excess silica ( $\text{SiO}_2$ ); allowed to stand for 12 hours, and then decanted.	0.30	0.0	0.0	0.1	0.1	0.1	0.06
5	(a.) Ringstone Reservoir, November 7th, 1894.	0.96	1.0	2.0	3.0	4.0	3.5	2.70
	(b.) The same water shaken with excess silica ( $\text{SiO}_2$ ); allowed to stand for 12 hours, and then decanted.	0.66	1.0	2.0	2.4	2.4	2.8	2.12
6	(a.) *Lowmoor Catch water, November 7th, 1894.	0.60	0.4	1.2	1.6	1.4	1.4	1.20
	(b.) The same water after shaking with excess silica ( $\text{SiO}_2$ ); allowed to stand for 12 hours, and then decanted.	0.30	0.0	0.2	0.2	0.2	0.4	0.20
7	(a.) Shipley water, November 13th, 1894.	1.02	2.0	3.0	3.5	4.0	4.0	3.30
	(b.) The same water after shaking with excess silica ( $\text{SiO}_2$ ); allowed to stand for 12 hours, and then decanted.	0.84	1.5	2.5	2.5	3.5	3.0	2.60

\* The sample of water was taken from a point just before entering Ringstone Reservoir. N.B.—0.1 per cent. of silica ( $\text{SiO}_2$ ) was used in each case.

It will be noted that, under the conditions of experiment, silica ( $\text{SiO}_2$ ) had seemingly some slight effect in reducing the acidity and plumbo-solvent ability of the various waters. Nevertheless, at the end of the experiment, the waters remained in a dangerous condition as regards potential solvent action on lead.

The following table (XCIX.) shows the effect, as regards plumbo-solvency, of the addition to various acid waters of measured quantities of a hard limestone water (Settle Public Supply) :—

TABLE XCIX.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of a hard LIMESTONE WATER (Settle Public Supply).

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Shipley water, July 15th, 1894 - -	1.5	2.5	3.0	3.0	3.0	2.60
	The same water, 5 parts, with 1 part Settle water.	0.0	0.0	0.0	0.0	0.0	0.00
2	Mossley water, July 15th, 1894 - -	0.1	0.4	0.5	0.6	0.6	0.44
	The same water, 50 parts, with 1 part Settle water.	0.0	0.1	0.1	0.2	0.2	0.12
3	Shipley water, July 23rd, 1894 - -	1.0	2.0	3.0	3.5	4.0	2.70
	The same water 10 parts, with 1 part Settle water.	0.0	0.1	0.1	0.2	0.2	0.12
4	Mossley water, July 24th, 1894 - -	0.0	0.3	0.5	0.6	0.7	0.42
	The same water, 10 parts, with 1 part Settle water.	0.0	0.0	0.0	0.0	0.0	0.00
5	Shipley water, August 6th, 1894 - -	0.5	2.0	2.5	3.0	2.5	2.10
	The same water, 10 parts, with 1 part Settle water.	0.0	0.1	0.2	0.2	0.2	0.14
6	Mossley water August 7th, 1894 - -	0.1	0.4	0.6	0.8	0.9	0.56
	The same water, 50 parts, with 1 part Settle water.	0.0	0.1	0.2	0.3	0.3	0.12
	The same water, 10 parts, with 1 part Settle water.	0.0	0.0	0.0	0.0	0.0	0.00
7	Shipley water, August 13th, 1894 - -	1.0	2.5	2.0	3.0	2.0	2.10
	The same water, 5 parts, with 1 part Settle water.	0.0	0.0	0.0	0.0	0.0	0.00
8	Morley water, August 17th, 1894 - -	0.0	0.1	0.4	0.6	0.7	0.36
	The same water, 10 parts, with 1 part Settle water.	0.0	0.0	0.0	0.0	0.0	0.00

TABLE XCIX.—*continued.*

Experiment.	Description of the Sample of Water.	Action on Lead (Results stated as Parts per 100,000).					
		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
9	Shipley water, August 21st, 1894 - -	2.0	4.0	4.0	5.0	5.0	4.00
	The same water, 5 parts, with 1 part Settle water.	0.0	0.0	0.0	0.0	0.0	0.00
10	Mossley water, August 21st, 1894 - -	0.1	0.3	0.4	0.7	0.8	0.46
	The same water, 10 parts, with 1 part Settle water.	0.0	0.0	0.0	0.0	0.0	0.00
11	Shipley water, August 27th, 1894 - - *(Hardness = 5.4.)	1.0	3.0	3.0	3.0	3.0	2.60
	The same water, 6 parts, with 1 part Settle water. *(Hardness = 6.3.)	0.0	0.0	0.0	0.0	0.0	0.00
12	Mossley water, August 28th, 1894 - - *(Hardness = 2.8.)	0.2	0.4	0.7	0.8	0.8	0.58
	The same water, 12 parts, with 1 part Settle water. *(Hardness = 4.5.)	0.0	0.0	0.0	0.0	0.0	0.00
13	Shipley water, September 3rd, 1894 - - *(Hardness = 5.3.)	1.0	3.0	3.0	4.0	3.0	2.80
	The same water, 6 parts, with 1 part Settle water. *(Hardness = 6.7.)	0.0	0.0	0.0	0.0	0.0	0.00
14	Mossley water, September 4th, 1894 - - *(Hardness = 2.8.)	0.1	0.3	0.6	0.7	0.8	0.50
	The same water, 12 parts, with 1 part Settle water. *(Hardness = 4.6.)	0.0	0.0	0.0	0.0	0.0	0.00

\* CaCO<sub>3</sub> parts per 100,000.

The results clearly show the great reduction in plumbo-solvent ability which results from the mixture of a soft acid moorland water with a hard water possessed of a considerable degree of acid-neutralising ability. It will be noted that an admixture of one part in six of Settle water with Shipley water so altered the character of the latter that it lost altogether its power of dissolving lead. When the proportion of Shipley water to Settle water was as ten to one, a feeble solvent action on lead occurred; but it was so slight in character, in comparison with the plumbo-solvent ability of "untreated" Shipley water, as to be almost negligible. Mossley and Morley waters containing 10 per cent. of Settle water were changed from waters possessed of decided plumbo-solvent ability into waters destitute of any appreciable solvent action on lead. Even 2 per cent. of Settle water modified, to a striking extent, the plumbo-solvent power of Mossley water.

In the following table (Table C.) the effect, as regards plumbo-solvency, of the addition to various acid waters of measured quantities of ammonium carbonate is shown :—

TABLE C.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to various ACID WATERS of MEASURED QUANTITIES of AMMONIUM CARBONATE  $(\text{NH}_4)_2\text{CO}_3$ .

[The action on lead was tested by upward filtration through 50 c.c. washed shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Re-action.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Shipley water, June 4th, 1894	Acid	3·0	4·0	4·0	4·0	5·0	4·00
	The same water, + 0·1 per cent. ammonium carbonate.	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
2	Shipley water, October 30th, 1894	Acid	1·0	3·0	3·0	4·0	4·0	3·00
	The same water, + 0·1 per cent. $(\text{NH}_4)_2\text{CO}_3$ .	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
3	Mossley water, October 30th, 1894.	Acid	0·0	0·1	0·2	0·4	0·5	0·24
	The same water, + 0·1 per cent. $(\text{NH}_4)_2\text{CO}_3$ .	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
4	Shipley water, November 5th, 1894.	Acid	3·0	2·5	3·5	3·0	3·0	2·80
	The same water, + 0·1 per cent. $(\text{NH}_4)_2\text{CO}_3$ .	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
5	Mossley water, November 6th, 1894.	Acid	0·1	0·4	0·5	0·6	0·6	0·44
	The same water, + 0·1 per cent. $(\text{NH}_4)_2\text{CO}_3$ .	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
6	Mossley water, November 20th, 1894.	Acid	0·1	0·2	0·3	0·4	0·4	0·28
	The same water, + 0·1 per cent. $(\text{NH}_4)_2\text{CO}_3$ .	Neutral	0·0	0·0	0·0	0·0	0·0	0·00

It will be seen that ammonium carbonate, in the proportion of 0·1 per cent., sufficed to neutralise the waters, and thereby to remove their plumbo-solvent ability.



Table CI. shows the effect, as regards plumbo-solvency, of the neutralisation of certain acid waters by lime water.

TABLE CI.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the NEUTRALISATION of certain ACID WATERS by LIME WATER.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Hardness CaCO <sub>3</sub> parts per 100,000.	Action on Lead (Results stated as Parts per 100,000).					Average.
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1	Mossley water, October 16th, 1894	2·8	0·2	0·6	0·9	0·8	1·0	0·70
	The same water after neutralisation with lime water.	3·9	0·0	0·0	0·0	0·0	0·0	0·00
2	Mossley water, October 30th, 1894	3·5	0·0	0·1	0·2	0·4	0·5	0·24
	The same water after neutralisation with lime water.	5·2	0·0	0·0	0·0	0·0	0·0	0·00
3	Mossley water, November 6th, 1894.	3·8	0·1	0·4	0·5	0·6	0·6	0·44
	The same water after neutralisation with lime water.	5·2	0·0	0·0	0·0	0·0	0·0	0·00
4	Ardsley untreated water, November 15th, 1894.	—	2·0	2·5	3·0	3·0	3·0	2·70
	The same water after neutralisation with lime water.	—	0·0	0·0	0·0	0·0	0·0	0·00
5	Mossley water, November 20th, 1894.	3·8	0·1	0·2	0·3	0·4	0·4	0·28
	The same water after neutralisation with lime water.	4·9	0·0	0·0	0·0	0·0	0·0	0·00
6	Dunford Reservoir, November 24th, 1894.	—	0·1	0·4	0·5	0·6	0·6	0·44
	The same water after neutralisation with lime water.	—	0·0	0·0	0·0	0·0	0·0	0·00
7	Mossley water, November 27th, 1894.	—	0·1	0·4	0·4	0·4	0·5	0·36
	The same water after neutralisation with lime water.	—	0·0	0·0	0·0	0·0	0·0	0·00

It is to be noted that neutralisation with lime water rendered the moorland waters less "soft" than before; by neutralising their acidity it changed them from acid plumbo-solvent waters into neutral non-plumbo-solvent waters.

In the following table (Table CII.) the effect is shown, as regards plumbo-solvency, of the addition to certain acid waters of measured quantities of powdered chalk:—

TABLE CII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the addition to certain ACID WATERS of MEASURED QUANTITIES of POWDERED CHALK ( $\text{CaCO}_3$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed shot at the rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Sample of Water.	Re-action.	Action on Lead (Results expressed as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	Distilled water boiled, allowed to cool; $\text{CO}_2$ passed through for $\frac{1}{2}$ hour.	Acid	2.8	2.8	2.8	2.8	2.8	2.80
	Distilled water boiled, allowed to cool; $\text{CO}_2$ passed through for $\frac{1}{2}$ hour, left in contact excess powdered limestone for $1\frac{1}{2}$ hours, filtered.	Faintly acid.	0.2	0.1	0.1	0.1	0.0	0.10
2	Distilled water X (acid reaction)	Acid	0.2	0.4	0.6	0.6	0.6	0.48
	The same water shaken with excess $\text{CaCO}_3$ (powdered chalk) for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
3	Mossley water, January 26th, 1894	Acid	0.1	0.1	0.1	0.1	0.2	0.12
	Same water shaken with excess $\text{CaCO}_3$ (powdered chalk) for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
4	Mossley water, February 1st, 1894	Acid	0.0	0.1	0.1	0.1	0.2	0.10
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
5	Shipley water, February 2nd, 1894	Acid	1.2	2.8	2.8	2.8	3.0	2.52
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
6	Shipley water, February 3rd, 1894	Acid	1.6	3.2	3.4	4.0	4.0	3.24
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
7	Settle Peat Pool, February 3rd, 1894.	Acid	0.0	0.1	0.3	0.5	0.6	0.30
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
8	Settle Peat Pool, February 5th, 1894.	Acid	0.0	0.1	0.2	0.3	0.3	0.12
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
9	Settle Peat Pool, February 8th, 1894.	Acid	0.1	0.2	0.4	0.5	0.6	0.28
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
10	Mossley water, February 9th, 1894.	Acid	0.0	0.0	0.1	0.1	0.2	0.08
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CII.—*continued.*

Experiment.	Description of the Sample of Water.	Re-action.	Action on Lead (Results expressed as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
11	Mossley water, February 16th, 1894.	Acid	0.0	0.1	0.2	0.2	0.2	0.14
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
12	Mossley water, February 20th, 1894.	Acid	0.0	0.1	0.2	0.2	0.3	0.16
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
13	Settle Peat Pool, February 24th, 1894.	Acid	0.2	1.0	1.2	1.2	1.2	0.96
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
14	Shipley water, February 27th, 1894.	Acid	0.8	2.0	2.4	2.8	3.2	2.24
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
15	Settle Peat Pool, February 28th, 1894.	Acid	0.4	0.9	1.0	1.2	1.2	0.94
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
16	Settle Peat Pool, March 2nd, 1894.	Acid	0.2	0.4	1.0	1.2	1.2	0.80
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered.	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
17	Shipley water, October 8th, 1894 (Hardness = 5.3).*	Acid	2.0	3.0	3.5	3.5	4.0	3.20
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered. (Hardness = 12.6).*	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
18	Mossley water, October 10th, 1894. (Hardness = 2.8).*	Acid	0.1	0.4	0.7	0.8	1.0	0.60
	The same water, shaken with excess $\text{CaCO}_3$ for $\frac{1}{2}$ hour, filtered. (Hardness = 9.1).*	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
19	Mossley water, November 5th, 1894. (Hardness = 3.8).*	Acid	0.1	0.4	0.5	0.6	0.6	0.44
	The same water left overnight in contact with excess $\text{CaCO}_3$ and decanted (Hardness = 6.7).*	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

\* Results stated as parts  $\text{CaCO}_3$  per 100,000.  
N.B.—Excess of  $\text{CaCO}_3$ , meant 0.1 per cent.

The above table includes an experiment (Experiment 1) in which previously boiled distilled water was saturated with  $\text{CO}_2$ . The water in consequence was strongly acid and dissolved lead to a marked extent. A similarly treated water, after intimate contact with powdered limestone, lost almost completely its acidity and plumbo-solvent ability. As regards the naturally acid and plumbo-solvent waters, these in each case, after "treatment" with chalk, lost their acidity and power to dissolve lead.

The following table (Table CIII.) is an important one. It shows the effect, as regards plumbo-solvency, of the neutralisation of acid-moorland waters with sodium carbonate.

TABLE CIII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the NEUTRALISATION of certain ACID MOORLAND WATERS with SODIUM CARBONATE ( $\text{Na}_2\text{CO}_3$ ).

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at the rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c. c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
			1st 50 c.c.	2nd. 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) July 16, 1894, *Shipley water (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 1'26 0'00	1'5 0'0	2'5 0'0	3'0 0'0	3'0 0'0	3'0 0'0	2'60 0'00
2	(a.) †Morley water, August 25, 1894. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'30 0'00	0'0 0'0	0'1 0'0	0'2 0'0	0'2 0'0	0'2 0'0	0'14 0'00
3	(a.) August 25, 1894, ‡Jack Clough water. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'48 0'00	0'0 0'0	0'2 0'0	0'4 0'0	0'5 0'0	0'6 0'0	0'34 0'00
4	(a.) August 25, 1894, §Within's Main Stream. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'48 0'00	0'0 0'0	0'2 0'0	0'5 0'0	0'6 0'0	0'7 0'0	0'40 0'00
5	(a.) August 25, 1894,   Fletcher's Dyke Stream. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 1'70 0'00	3'0 0'0	6'0 0'0	6'0 0'0	6'0 0'0	7'0 0'0	5'60 0'00
6	(a.) *Shipley water, August 27, 1894. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 1'08 0'00	1'0 0'0	3'0 0'0	3'0 0'0	3'0 0'0	3'0 0'0	2'60 0'00
7	(a.) †Wakefield water, September 14, 1894. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'84 0'00	0'8 0'0	2'0 0'0	2'4 0'0	2'4 0'0	2'4 0'0	2'00 0'00
8	(a.) September 14, 1894, **Yeomen Reservoir water. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'48 0'00	0'1 0'0	0'2 0'0	0'3 0'0	0'6 0'0	0'7 0'0	0'38 0'00
9	(a.) September 14, 1894, **Lower Swineshaw Reservoir water. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'48 0'00	0'1 0'0	0'5 0'0	0'7 0'0	1'0 0'0	1'0 0'0	0'68 0'00
10	(a.) September 14, 1894, **Higher Swineshaw Reservoir water. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'60 0'00	0'4 0'0	1'0 0'0	1'2 0'0	1'2 0'0	1'2 0'0	1'00 0'00
11	(a.) †Wakefield water, November 13, 1894. (b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	p.p. 0'90 0'00	2'0 0'0	2'5 0'0	3'0 0'0	3'0 0'0	3'0 0'0	2'70 0'00

TABLE CIII.—continued.

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{10}{100}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Result stated as Parts per 100,000).					
			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
12	(a.) †† Mossley water, November 20, 1894.	p.p. 0.30	0.1	0.2	0.3	0.4	0.4	0.28
	(b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.0	0.0	0.0	0.0	0.0	0.00
13	(a.) †† Dunford Bridge Reservoir water, November 24, 1894.	p.p. 0.42	0.1	0.4	0.5	0.6	0.6	0.44
	(b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.0	0.0	0.0	0.0	0.0	0.00
14	(a.) †† Mossley water, November 27, 1894.	p.p. 0.30	0.1	0.4	0.4	0.4	0.5	0.36
	(b.) The same water after neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.0	0.0	0.0	0.0	0.0	0.00
15	(a.) * Shipley water, March 26, 1895.	m.o. 0.24	1.5	2.0	2.0	2.0	2.5	2.00
	(b.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.4	0.8	0.8	1.0	1.2	0.84
16	(a.) * Shipley water, April 2, 1895	m.o. 0.30	2.0	2.5	3.0	3.0	3.0	2.70
	(b.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.4	0.8	0.8	1.2	1.2	0.88
	(c.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.74	1.24	1.24	1.24	1.24	1.14
17	(a.) * Shipley water, April 9, 1895	m.o. 0.24	1.5	2.0	2.0	2.5	2.5	2.10
	(b.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.4	1.0	1.2	1.4	1.4	1.08
18	(a.) * Shipley water, April 16, 1895.	m.o. 0.18	0.5	1.0	1.5	1.5	1.0	1.20
	(b.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.2	0.4	0.6	0.6	0.6	0.48
	(c.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.4	0.6	1.0	1.0	1.0	0.80
19	(a.) * Shipley water, April 23, 1895.	m.o. 0.18	1.0	1.5	2.0	2.0	2.0	1.70
	(b.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.8	1.2	1.2	1.4	1.6	1.24
20	(a.) * Shipley water, April 30, 1895.	m.o. 0.30	1.5	2.5	2.5	2.5	2.0	2.20
	(b.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.6	1.0	1.2	1.4	1.4	1.12
21	(a.) * Shipley water, May 7, 1895	m.o. 0.18	1.0	1.0	1.5	1.5	2.0	1.40
	(b.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.4	0.8	0.8	0.8	0.8	0.72
	(c.) The same water after † neutralisation with $\text{Na}_2\text{CO}_3$ .	0.00	0.4	0.8	1.0	1.0	1.0	0.64

\* The water was taken from Eldwick Reservoir (near Bingley). Shipley water supply.  
† The water was taken from Within's Reservoir (near Mytholmroyd). Morley water supply.  
‡ One of the feeders to Within's Reservoir (near Mytholmroyd). Morley water supply.  
§ Main inlet stream to Within's Reservoir. Morley water supply.  
|| One of the feeders to Within's Reservoir. Morley water supply.  
¶ The water was taken from Ardsley Reservoir. Wakefield water supply (before treatment).  
\*\* Ashton, Stalybridge, Dukinfield, and Mossley Waterworks.  
†† Mossley main water.  
‡‡ Dewsbury and Hecknold Waterworks.  
p.p. Phenolphthalein was used as indicator.  
m.o. Methyl-orange was used as indicator.

The result of complete neutralisation was the same in all cases namely, that the water completely lost its plumbo-solvent ability. Even partial neutralisation was satisfactory, since it reduced the solvent action on lead in rough correspondence with the amount of sodium carbonate employed; 21 samples in all were tested, and these were obtained from eleven different sources.

The following nine tables show the effect, as regards plumbosolvency, of filtering acid moorland waters through Iceland Spar (CIV.), asbestos (CV.), coke (CVI.), polarite (CVII.), limestone (CVIII.), sand (CIX.), marble (CX.), chalk (CXI.), and flint (CXII.).

TABLE CIV.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the FILTRATION of various ACID MOORLAND WATERS through ICELAND SPAR.

[The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) June 4th, 1894, Shipley water.	6.7	1.3	3.0	4.0	4.0	4.0	5.0	4.00
	(b.) The same water after upward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 15 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
2	(a.) June 6th, 1894, Mossley water.	3.5	0.42	0.2	0.6	0.8	0.9	0.9	0.68
	(b.) The same water after upward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 19 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
3	(a.) July 23rd, 1894, Shipley water.	4.9	1.02	1.0	2.0	3.0	3.5	4.0	2.70
	(b.) The same water after upward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 27 seconds per 50 c.c.	—	Faintly acid.	0.2	0.6	0.8	1.2	1.2	0.80
4	(a.) July 24th, 1894, Mossley water.	3.36	0.42	0.0	0.3	0.5	0.6	0.7	0.42
	(b.) The same water after upward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 27 seconds per 50 c.c.	—	Trace	0.0	0.0	0.0	0.1	0.1	0.04

TABLE CIV.—*continued.*

Experiment.	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
5	(a.) August 6th, 1894, Shipley water.	4.9	1.08	0.5	2.0	2.5	3.0	2.5	2.10
	(b.) The same water after downward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 70 seconds per 50 c.c.	—	Trace	0.0	0.0	0.1	0.2	0.3	0.12
	(c.) Same as (b.) but at rate of 15 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
6	(a.) August 7th, 1894, Mossley water.	3.5	0.48	0.1	0.4	0.6	0.8	0.9	0.56
	(b.) The same water after downward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 35 seconds per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
7	(a.) January 21st, 1895, Shipley water.	4.9	1.02	1.0	2.5	2.5	3.0	3.0	2.40
	(b.) The same water after downward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 15 seconds per 10 c.c.	4.9	0.66	0.5	0.5	0.5	0.5	0.5	0.50
8	(a.) January 29th, 1895, Shipley water.	5.4	0.96	1.0	2.5	2.5	2.5	2.5	2.20
	(b.) The same water after downward filtration through 50 c.c. Iceland Spar (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 2 minutes 5 seconds per 10 c.c.	6.7	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CV.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the FILTRATION of various ACID MOORLAND WATERS through ASBESTOS.

[The action on lead was tested by upward filtration through 50 c.c washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) September 10th, 1894, Shipley water.	4.2	0.96	1.0	2.0	2.0	2.5	2.5	2.00
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " diameter) at rate of 9 minutes per 50 c.c.	4.2	0.78	0.5	2.5	2.0	2.0	2.5	1.90
2	(a.) September 11th, 1894, Mossley water.	2.8	0.42	0.2	0.5	0.6	0.8	0.8	0.58
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " diameter) at rate of 10 minutes per 50 c.c.	—	0.36	0.1	0.3	0.5	0.6	0.8	0.46
3	(a.) October 23th, 1894, Black Dyke water.	5.2	1.20	3.0	5.0	5.0	5.0	5.5	4.70
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " diameter) at rate of 1 minute per 10 c.c.	4.9	1.02	3.0	4.0	4.5	5.0	5.0	4.30
4	(a.) November 5th, 1894, Shipley water.	5.6	1.02	2.0	2.5	3.5	3.0	3.0	2.80
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " diameter) at rate of 1 minute per 10 c.c.	5.46	0.90	1.5	2.5	3.5	3.5	3.5	2.90
5	(a.) February 12th, 1895, Shipley water.	4.9	0.78	1.0	1.5	1.5	2.0	2.0	1.60
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " diameter) at rate of 3 minutes and 10 seconds per 10 c.c.	—	0.66	1.0	1.5	1.5	1.5	2.0	1.50



TABLE CV.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. of $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
6	(a.) April 9th, 1895, Shipley water.	5.3	0.84	1.5	2.0	2.0	2.5	2.5	2.10
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " dia- meter) at rate of 2½ minutes per 10 c.c.	—	0.72	1.0	2.0	2.0	2.0	2.0	1.80
7	(a.) April 16th, 1895, Shipley water.	5.3	0.72	0.5	1.0	1.5	1.5	1.5	1.20
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " dia- meter) at rate of 3 minutes per 10 c.c.	—	0.60	0.8	1.4	1.4	1.4	1.4	1.23
8	(a.) April 23rd, 1895, Shipley water.	5.6	0.78	1.0	1.5	2.0	2.0	2.0	1.70
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " dia- meter) at rate of 3 minutes per 10 c.c.	—	0.66	0.8	1.4	1.6	1.8	2.0	1.53
9	(a.) April 30th, 1895, Shipley water.	6.86	0.96	1.5	2.5	2.5	2.5	2.0	2.20
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " dia- meter) at rate of 3 minutes per 10 c.c.	—	0.84	2.0	3.0	3.5	3.0	3.0	2.90
10	(a.) May 7th, 1895, Shipley water.	6.0	0.78	1.0	1.0	1.5	1.5	2.0	1.40
	(b.) The same water after downward filtration through 10 c.c. asbestos in burette ( $\frac{1}{2}$ " dia- meter) at rate of 4 minutes per 10 c.c.	—	0.66	1.5	2.0	2.0	2.5	2.0	2.00

TABLE CVI.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the FILTRATION of ACID MOORLAND WATERS through COKE.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) July 16th. 1894, Shipley water.	4.48	1.28	1.5	2.5	3.0	3.0	3.0	2.60
	(b.) The same water after upward filtration through 50 c.c. coke (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 6 minutes per 50 c.c.	—	0.60	0.1	0.5	0.9	1.0	1.0	0.70
2	(a.) July 16th. 1894, Mossley water.	3.1	0.42	0.1	0.4	0.5	0.6	0.6	0.44
	(b.) The same water after upward filtration through 50 c.c. coke (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 6 minutes per 50 c.c.	—	0.24	0.0	0.0	0.1	0.1	0.1	0.06
3	(a.) August 6th. 1894, Shipley water.	4.9	1.08	0.5	2.0	2.5	3.0	2.5	2.10
	(b.) The same water after downward filtration through 50 c.c. coke (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 6 minutes per 50 c.c.	—	—	0.4	2.0	2.2	2.2	2.4	1.84
4	(a.) August 7th. 1894, Mossley water.	3.5	0.48	0.1	0.4	0.6	0.8	0.9	0.56
	(b.) The same water after downward filtration through 50 c.c. coke (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of $2\frac{1}{2}$ minutes per 50 c.c.	—	Faintly acid.	0.0	0.1	0.2	0.2	0.3	0.16
5	(a.) September 10th. 1894, Shipley water.	4.2	0.96	1.0	2.0	2.0	2.5	2.5	2.00
	(b.) The same water after downward filtration through 50 c.c. coke (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 3 minutes per 50 c.c.	5.6	0.60	0.2	0.3	1.2	1.2	1.4	0.96

TABLE CVI.—*continued.*

Experiment.	Description of the Experiment.	Hard-ness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
6	(a.) May 14th, 1895, Shipley water.	5.74	0.78	1.0	2.0	2.0	2.0	2.0	1.80
	(b.) The same water after downward filtration through 50 c.c. coke (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of $7\frac{1}{2}$ minutes per 50 c.c.	6.02	0.60	0.6	1.4	1.6	1.6	1.6	1.36

TABLE CVII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the FILTRATION  
of ACID MOORLAND WATERS through POLARITE.

[The action on lead was tested by means of upward filtration through  
50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Hard-ness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Lead Action (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) September 28th, 1894, Watershed- dels Reservoir water	2.50	0.48	0.2	0.7	0.9	1.2	1.2	0.84
	(b.) The same water after upward fil- tration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 2 minutes per 50 c.c.	2.80	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
2	(a.) September 28th, 1894, water of acid peat feeder to Watersheddels Reservoir (No. 13).	2.50	0.60	0.4	0.8	0.9	0.9	1.0	0.80
	(b.) The same water after upward fil- tration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 2 minutes per 50 c.c.	2.50	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CVII.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ N <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Lead Action (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
3	(a.) October 1st, 1894, Shipley water.	5.20	0.90	1.0	3.0	3.0	3.0	4.0	2.80
	(b.) The same water after upward fil- tration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 6 minutes per 50 c.c.	3.90	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but at quicker rate, viz., 20 seconds per 50 c.c.	4.50	0.66	0.6	1.4	2.0	2.0	2.0	1.60
4	(a.) October 2nd, 1894, Mossley water.	3.20	0.48	0.2	0.6	1.0	1.0	1.2	0.80
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 4 minutes per 50 c.c.	3.20	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
5	(a.) October 4th, 1894, Rinkstone Re- servoir water.	3.90	0.66	1.0	2.0	2.4	2.4	2.4	2.04
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 4 minutes per 50 c.c.	3.50	0.30	0.0	0.3	0.5	0.6	0.6	0.40
6	(a.) December 17th, 1894, Shipley water.	5.50	1.20	2.5	3.0	3.5	3.5	4.0	3.30
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 6 minutes and 40 seconds per 50 c.c.	4.60	0.54	0.8	1.0	1.2	1.6	1.6	1.24
7	(a.) May 17th, 1895, unfiltered Keigh- ley water.	3.64	0.54	0.7	0.9	1.0	1.0	1.1	0.94
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of $7\frac{1}{2}$ minutes per 50 c.c.	4.20	0.24	0.1	0.3	0.4	0.4	0.4	0.32

TABLE CVII.—*continued.*

Experiment.	Description of the Experiment.	Hard-ness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Lead Action (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
8	(a.) May 21st, 1895, Shipley water.	6'00	0'72	1'0	1'5	2'0	2'0	2'0	1'70
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 8½ minutes per 50 c.c.	5'90	0'54	0'6	1'0	1'2	1'2	1'2	1'04
9	(a.) May 28th, 1895, Shipley water.	6'40	0'78	1'5	2'5	3'0	2'5	2'5	2'40
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 18½ minutes per 50 c.c.	5'50	0'36	0'3	0'4	0'5	0'5	0'5	0'44
10	(a.) June 4th, 1895, Shipley water.	7'30	0'96	2'0	2'5	2'5	2'5	2'5	2'40
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 25 minutes per 50 c.c.	6'00	0'42	0'3	0'5	0'6	0'6	0'6	0'53
11	(a.) June 6th, 1895, Keighley unfiltered water.	3'90	0'54	0'4	0'8	0'8	1'0	1'2	0'84
	(b.) The same water after downward filtration through 50 c.c. polarite (small pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 25 minutes per 50 c.c.	3'20	0'24	0'0	0'0	0'0	Trace	Trace	Trace

TABLE CVIII.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the FILTRATION of certain ACID MOORLAND WATERS through LIMESTONE.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{N}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Lead Action (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) September 10th, 1894, Shipley water.	4.2	0.96	1.0	2.0	2.0	2.5	2.5	2.00
	(b.) The same water after downward filtration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 3 minutes per 50 c.c.	5.6	0.30	0.0	0.0	0.0	0.1	0.1	0.04
2	(a.) September 11th, 1894, Mossley water.	2.8	0.42	0.2	0.5	0.6	0.8	0.8	0.58
	(b.) The same water after downward filtration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 3 minutes per 50 c.c.	3.8	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
3	(a.) October 2nd, 1894, Mossley water.	3.2	0.48	0.2	0.6	1.0	1.0	1.2	0.80
	(b.) The same water after downward filtration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 4 minutes per 50 c.c.	3.9	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
4	(a.) October 4th, 1894, Ringstone Reservoir water.	3.9	0.66	1.0	2.0	2.4	2.4	2.4	2.04
	(b.) The same water after downward filtration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 4 minutes per 50 c.c.	4.6	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
5	(a.) October 10th, 1894, Mossley water.	2.8	0.48	0.1	0.4	0.7	0.8	1.0	0.60
	(b.) The same water after upward filtration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 1 minute and 40 seconds per 50 c.c.	3.2	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CVIII.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Lead Action (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
6	(a.) October 15th, 1894, Shipley water.	4.9	0.90	1.0	3.0	3.0	3.0	4.0	2.80
	(b.) The same water after upward fil- tration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 40 seconds per 50 c.c.	5.2	0.54	0.0	1.0	2.0	2.0	2.0	1.40
7	(a.) November 26th, 1894, Shipley water.	5.6	0.90	0.5	1.5	2.0	2.5	2.0	1.70
	(b.) The same water after downward filtration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 5 minutes per 50 c.c. filtration repeated four times.	8.7	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
8	(a.) November 27th, 1894, Mossley water.	3.5	0.30	0.1	0.4	0.4	0.4	0.5	0.38
	(b.) The same water after downward filtration through 50 c.c. limestone (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 2 minutes 5 seconds per 50 c.c.	4.2	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CIX.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the FILTRATION of certain ACID MOORLAND WATERS through SAND.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) June 25th, 1894, Shipley water.	6.2	1.08	2.0	3.0	3.0	3.5	3.0	2.90
	(b.) The same water after upward filtration through 50 c.c. river sand* in burette ( $\frac{1}{4}$ " diameter) at rate of 15 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
2	(a.) June 27th, 1894, Mossley water.	4.2	0.54	0.2	0.5	0.6	0.7	0.8	0.56
	(b.) The same water after upward filtration through 50 c.c. river sand* in burette ( $\frac{1}{4}$ " diameter) at rate of 11 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
3	(a.) July 3rd, 1894, Shipley water.	5.3	1.08	2.0	3.0	3.0	3.0	3.0	2.80
	(b.) The same water after upward filtration through 50 c.c. river sand* in burette ( $\frac{1}{4}$ " diameter) at rate of 9 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
4	(a.) July 4th, 1894, Mossley water.	3.5	0.48	0.2	0.5	0.6	0.7	0.8	0.56
	(b.) The same water after upward filtration through 50 c.c. river sand* in burette ( $\frac{1}{4}$ " diameter) at rate of 9 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
5	(a.) July 9th, 1894, Shipley water.	5.46	1.14	1.0	2.0	2.5	3.0	3.0	2.30
	(b.) The same water after upward filtration through 50 c.c. river sand* in burette ( $\frac{1}{4}$ " diameter) at rate of 3 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

\* Sand obtained from bed of Giggleswick Beck.



TABLE CIX.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{n}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
6	(a.) July 10th, 1894, Mossley water.	—	0·6	0·1	0·5	0·7	0·8	0·8	0·58
	(b.) The same water after upward filtration through 50 c.c. river sand* in burette ( $\frac{1}{2}$ " diameter) at rate of 3 minutes per 50 c.c.	—	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
7	(a.) August 1th, 1894, Shipley water.	5·4	1·08	1·0	3·0	3·0	3·0	3·0	2·80
	(b.) The same water after downward filtration through 50 c.c. river sand* in burette ( $\frac{3}{4}$ " diameter) at rate of 25 minutes per 50 c.c.	—	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
8	(a.) September 3rd, 1894, Shipley water.	5·3	0·9	1·0	3·0	3·0	4·0	3·0	2·90
	(b.) The same water after downward filtration through 50 c.c. river sand* in burette ( $\frac{3}{4}$ " diameter) at rate of 23 minutes per 50 c.c.	10·6	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
9	(a.) September 4th, 1894, Mossley water.	2·8	0·36	0·1	0·3	0·6	0·7	0·8	0·50
	(b.) The same water after downward filtration through 50 c.c. river sand* in burette ( $\frac{3}{4}$ " diameter) at rate of 10 minutes per 50 c.c.	7·4	Neutral	0·0	0·0	0·0	0·0	0·0	0·00
10	(a.) January 8th, 1895, Shipley water.	4·9	0·9	1·5	3·0	3·0	3·0	3·0	3·70
	(b.) The same water after downward filtration through 50 c.c. Nith river sand in burette ( $\frac{3}{4}$ " diameter) at rate of 5 minutes per 50 c.c.	5·3	Trace	0·0	0·0	0·1	0·2	0·2	0·10
11	(a.) September 10th, 1894, Shipley water.	4·2	0·96	1·0	2·0	2·0	2·5	2·5	2·00
	(b.) The same water after downward filtration through 50 c.c. Gullane sea sand in burette ( $\frac{1}{2}$ " diameter) at rate of 10 minutes per 50 c.c.	7·0	Neutral	0·0	0·0	0·0	0·0	0·0	0·00

\* Sand obtained from bed of Glegleswick Beck.

TABLE CIX.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
12	(a.) September 11th, 1894, Mossley water.	2.8	0.42	0.2	0.5	0.6	0.8	0.8	0.58
	(b.) The same water after downward filtration through 50 c.c. Gullane sea sand in burette ( $\frac{1}{2}$ " diameter) at rate of 10 minutes per 50 c.c.	9.8	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but sand previously washed free of calcareous matter, &c., with dilute HCl. and then with distilled water to remove the acid.	4.6	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
13	(a.) September 14th, 1894, Wakefield untreated water from Ardsley Reservoir.	3.8	0.84	0.8	2.0	2.4	2.4	2.4	2.00
	(b.) The same water after downward filtration through 10 c.c. Gullane sea sand at rate of 4 minutes per 50 c.c.	6.0	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but sand previously washed free of calcareous matter with dilute HCl and then with distilled water to remove the acid.	3.8	0.6	1.0	1.6	2.0	2.4	2.6	1.92
14	(a.) September 17th, 1894, Shipley water.	4.9	0.96	1.0	2.0	3.0	3.0	3.0	2.40
	(b.) The same water after downward filtration through 50 c.c. Gullane sea sand previously treated with HCl and washed free of acid at rate of 10 minutes per 50 c.c.	5.3	0.49	0.2	1.2	1.6	1.6	1.6	1.24
15	(a.) September 18th, 1894, Mossley water.	3.5	0.48	0.2	0.4	0.6	0.8	0.9	0.58
	(b.) The same water after downward filtration through 10 c.c. Gullane sea sand previously treated with HCl and washed free of acid at rate of 10 minutes per 50 c.c.	3.5	0.36	0.2	0.6	0.8	0.9	0.9	0.68

TABLE CIX.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{w}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
16	(a.) September 25th, 1894, Shipley water.	5.3	0.9	1.0	2.0	2.0	2.5	3.0	2.10
	(b.) The same water after downward filtration through 10 c.c. Gullane sea sand at rate 25 seconds per 50 c.c.	5.6	0.42	0.0	0.2	0.4	0.5	0.6	0.34
	(c.) Same as (b.), but sand previously treated with HCl and washed free of acid.	5.3	0.84	1.0	2.0	2.5	2.5	2.5	2.10
17	(a.) September 25th 1894, Mossley water.	3.2	0.42	0.3	0.7	0.8	0.9	0.9	0.72
	(b.) The same water after downward filtration through 10 c.c. Gullane sea sand at rate of 25 seconds per 50 c.c.	3.6	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but sand previously treated with HCl and washed free of acid.	3.2	0.36	0.2	0.5	0.6	1.0	1.0	0.66
18	(a.) October 8th, 1894, Shipley water.	5.3	1.08	2.0	3.0	3.5	3.5	4.0	3.20
	(b.) The same water after downward filtration through 20 c.c. Shipley sandstone sand at rate of 4 minutes per 50 c.c.	4.9	1.08	1.0	2.0	3.5	3.5	3.0	2.60
	(c.) Same as (b.), but Gullane sea sand used.	7.0	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
19	(a.) October 10th, 1894, Mossley water.	2.8	0.48	0.1	0.4	0.7	0.8	1.0	0.66
	(b.) The same water after upward filtration through 20 c.c. Gullane sea sand at rate of 100 seconds per 50 c.c.	4.1	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
20	(a.) October 16th, 1894, Mossley water.	2.8	0.48	0.2	0.6	0.9	0.8	1.0	0.70
	(b.) The same water after upward filtration through 50 c.c. Gullane sea sand at rate of 16 seconds per 10 c.c.	5.6	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but sand previously treated with HCl and washed free of acid. Rate of filtration 1 minute per 50 c.c.	2.3	0.24	0.1	0.1	0.1	0.2	0.4	0.18

TABLE CIX.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
21	(a.) November 13th, 1894, Shipley water.	5.9	1.02	2.0	3.0	3.5	4.0	4.0	3.30
	(b.) The same water after downward filtration through 25 c.c. Gullane sea sand at rate of 1 minute per 10 c.c.	9.8	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but sand previously treated with HCl and washed free of acid.	5.5	0.78	1.5	2.0	2.0	3.0	3.0	0.30
22	(a.) November 19th, 1894, Shipley water.	6.2	1.08	1.5	3.0	2.5	3.0	3.0	2.60
	(b.) The same water after downward filtration through 25 c.c. Shipley sandstone sand at rate of 40 seconds per 10 c.c.	6.2	0.96	2.0	2.5	2.5	2.5	2.5	2.40
	(c.) Same as (b.), but 50 c.c. sand and slower rate of filtration, viz., 70 seconds per 10 c.c.	6.0	0.96	1.0	1.5	1.5	1.5	1.5	1.40
23	(a.) November 26th, 1894, Shipley water.	5.6	0.9	0.5	1.5	2.0	2.5	2.0	1.70
	(b.) The same water after downward filtration through 50 c.c. Shipley sandstone sand at rate of 20 minutes per 25 c.c.	5.3	0.6	0.4	0.6	0.8	1.2	1.2	0.84
24	(a.) December 10th, 1894, Shipley water.	6.0	0.96	1.0	2.0	2.5	2.5	2.5	2.10
	(b.) The same water after downward filtration through 50 c.c. Gullane sea sand at rate of 1 minute and 20 seconds per 10 c.c.	9.1	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but sand previously treated with HCl and washed free of acid.	5.8	0.54	0.4	1.2	1.6	1.6	2.0	1.26
25	(a.) Shipley water, May 21st, 1896.	6.6	0.72	1.0	1.5	2.0	2.0	2.0	1.70
	(b.) Same as (a.), but water previously filtered through 25 c.c. Keighley sandstone sand at the rate of 1 minute and 45 seconds per 10 c.c.	6.2	0.66	1.2	1.8	2.0	2.2	2.2	1.88

TABLE CIX.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. 10% Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
26	(a.) May 17th, 1896, Keighley water.	3·8	0·48	0·4	0·6	0·8	0·8	1·0	0·72
	(b.) The same water after downward filtration through 50 c.c. Keighley sandstone sand at rate of 1 minute and 40 seconds per 10 c.c.	3·6	0·42	0·3	0·5	0·7	0·8	0·8	0·62
27	(a.) May 28th, 1896, Shipley water.	6·4	0·78	1·5	2·5	2·5	3·0	2·5	2·40
	(b.) The same water after downward filtration through 50 c.c. Keighley sandstone sand at rate of 2½ minutes per 10 c.c.	5·7	0·54	0·8	1·2	1·2	1·2	1·2	1·12
28	(a.) June 4th, 1896, Shipley water.	7·3	0·96	2·0	2·5	2·5	2·5	2·5	2·40
	(b.) The same water after downward filtration through 50 c.c. Keighley sandstone sand at rate of 4½ minutes per 10 c.c.	6·9	0·72	1·0	1·5	1·5	2·0	2·0	1·60
29	(a.) June 11th, 1896, Shipley water.	6·4	0·78	1·0	1·0	1·5	1·5	1·5	1·30
	(b.) The same water after downward filtration through 50 c.c. Keighley sandstone sand at rate of 5 minutes per 10 c.c.	5·9	0·48	0·4	0·4	0·8	0·8	1·0	0·68
30	(a.) June 18th, 1896, Shipley water.	6·3	0·72	1·0	2·0	2·0	2·0	2·0	1·80
	(b.) The same water after downward filtration through 50 c.c. Keighley sandstone sand at rate of 5 minutes per 10 c.c.	5·7	0·48	0·4	0·8	0·8	0·8	0·8	0·72

TABLE CX.

Showing the EFFECT, as regards PLUMBO-SOLVENCY, of the FILTRATION of certain ACID MOORLAND WATERS through MARBLE.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd. 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) June 11th, 1894, Shipley water.	4.9	1.20	1.5	3.0	3.0	3.0	4.0	2.90
	(b.) The same water after upward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 19 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
2	(a.) June 12th, 1894, Mossley water.	3.9	0.54	0.2	0.6	0.8	0.8	1.0	0.60
	(b.) The same water after upward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 19 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
3	(a.) July 23rd, 1894, Shipley water.	4.9	1.02	1.0	2.0	3.0	3.5	4.0	2.70
	(b.) The same water after upward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 27 seconds per 50 c.c.	—	Faintly acid.	0.1	0.4	0.7	0.8	1.0	0.60
4	(a.) July 24th, 1894, Mossley water.	3.36	0.42	0.0	0.3	0.5	0.6	0.7	0.42
	(b.) The same water after upward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 27 seconds per 50 c.c.	—	Very faintly acid.	0.0	0.0	0.0	0.1	0.1	0.04
5	(a.) July 30th, 1894, Shipley water.	—	1.08	0.5	2.0	2.0	2.0	2.0	1.70
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 25 seconds per 50 c.c.	—	Faintly acid.	0.1	0.2	0.3	0.3	0.4	0.25
	(c.) Same as (b.), but slower rate of filtration, viz., 5 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CX.—*continued.*

Experiment.	Description of the Experiment.	Hardness— CaCO <sub>3</sub> parts per 100,000	Acidity in Terms of c.c. of $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
6	(a.) July 31st, 1894, Mossley water.	—	0.42	0.1	0.4	0.5	0.6	0.6	0.44
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 14 seconds per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but slower rate of filtration, viz., 3 minutes per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
7	(a.) August 13th, 1894, Shipley water.	—	0.96	1.0	2.5	2.0	3.0	2.0	2.10
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 25 seconds per 50 c.c.	—	Faintly acid	0.1	0.2	0.3	0.4	0.4	0.28
	(c.) Same as (b.), but rate of filtration slower, viz., 2 minutes per 50 c.c.	—	Trace	0.0	0.0	0.1	0.1	0.2	0.08
8	(a.) August 14th, 1894, Mossley water.	—	0.48	0.0	0.2	0.4	0.6	0.8	0.40
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 13 seconds per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
9	(a.) August 17th, 1894, Morley water.	—	0.42	0.0	0.1	0.4	0.6	0.7	0.26
	(b.) The same water after downward filtration <i>twice</i> through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " diameter) at rate of 10 seconds per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
10	(a.) August 21st, 1894, Shipley water.	5.6	1.20	2.0	4.0	4.0	5.0	5.0	4.00
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 10 seconds per 50 c.c.	—	0.72	0.2	0.6	1.0	1.2	1.4	0.88
	(c.) Same as (b.), but filtration re- peated 6 times.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CX.—*continued.*

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> parts per 100,000	Acidity in Terms of c.c. of $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
11	(a.) August 21st, 1894, Mossley water.	2.8	0.42	0.1	0.3	0.4	0.7	0.8	0.46
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{2}$ " dia- meter) at rate of 10 seconds per 50 c.c.	—	0.30	0.0	0.0	0.1	0.1	0.2	0.08
	(c.) Same as (b.), but filtration re- peated 3 times.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
12	(a.) August 25th, 1894, Within's Reser- voir water.	4.6	0.30	0.0	0.1	0.2	0.2	0.2	0.14
	(b.) The same water after downward filtration <i>twice</i> through 50 c.c. marble (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 10 seconds per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
13	(a.) August 25th, 1894, Jack Clough water.	—	0.42	0.0	0.2	0.4	0.5	0.6	0.34
	(b.) The same water after downward filtration <i>thrice</i> through 50 c.c. marble (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 10 seconds per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
14	(a.) August 25th, 1894, Within's Main Stream water.	—	0.42	0.0	0.2	0.5	0.6	0.7	0.40
	(b.) The same water after downward filtration <i>thrice</i> through 50 c.c. marble (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 10 seconds per 50 c.c.	—	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
15	(a.) August 25th, 1894, Fletcher's Dyke water.	—	1.70	3.0	6.0	6.0	6.0	7.0	5.60
	(b.) The same water after downward filtration <i>thrice</i> through 50 c.c. marble (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 10 seconds per 50 c.c.	—	0.80	1.0	1.0	1.0	1.0	1.0	1.00
	(c.) Same as (b.), but water filtered <i>once</i> and at a slower rate of fil- tration, viz., 7 minutes per 50 c.c.	—	0.36	0.0	0.0	0.1	0.1	0.1	0.08



TABLE CX.—continued.

Experiment.	Description of the Experiment.	Hard-ness CaCO <sub>3</sub> parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralize 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
16	(a.) September 28th, 1894, Watershed- dels Reservoir water.	2.5	0.43	0.5	0.7	0.9	1.2	1.2	0.84
	(b.) The same water after very rapid downward filtra- tion through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) and fil- tration repeated until filtrate showed no acid reaction.	3.2	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	(c.) Same as (b.), but water filtered once and at a slower rate of fil- tration, viz., 5 minutes per 50 c.c.	3.8	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
17	(a.) September 28th, 1894, water of acid peat feeder to Watersheddels Reservoir (No. 13.)	2.5	0.6	0.4	0.8	0.9	0.9	1.0	0.80
	(b.) The same water after very rapid downward filtra- tion through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) and fil- tration repeated until filtrate showed no acid reaction.	3.5	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
18	(a.) October 1st, 1894, Shipley water.	5.2	0.9	1.0	3.0	3.0	3.0	4.0	2.80
	(b.) The same water after very rapid downward filtra- tion through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) and filtra- tion repeated until filtrate showed no acid reaction.	5.4	—	0.0	0.0	0.1	0.2	0.2	0.10
	(c.) Same as (b.), but water filtered twice and at a slower rate of filtration, viz., 5 minutes per 50 c.c.	5.6	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
19	(a.) October 2nd, 1894, Mossley water.	3.2	0.43	0.2	0.6	1.0	1.0	1.2	0.80
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 4 minutes per 50 c.c.	3.8	Neutral	0.0	0	0.0	0.0	0.0	0.00

TABLE CX.—continued.

Experiment.	Description of the Experiment.	Hardness CaCO <sub>3</sub> , parts per 100,000.	Acidity in Terms of c.c. of $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> , required to neu- tralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
20	(a.) October 4th, 1894, Ringstone Reser- voir water.	3.9	0.68	1.0	2.0	2.4	2.4	2.4	2.04
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 4 minutes per 50 c.c.	4.3	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
21	(a.) October 10th, 1894, Mossley water.	2.8	0.48	0.1	0.4	0.7	0.8	1.0	0.60
	(b.) The same water after upward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 100 seconds per 50 c.c.	3.3	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
22	(a.) October 15th, 1894, Shipley water.	4.9	0.9	1.0	3.0	3.0	3.0	4.0	2.80
	(b.) The same water after upward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 40 seconds per 50 c.c.	5.0	0.54	0.5	1.0	2.0	2.0	1.0	1.80
23	(a.) December 3rd, 1894. Shipley water.	5.4	0.84	1.5	2.0	2.5	2.5	2.5	2.20
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 7½ minutes per 50 c.c.	6.7	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
24	(a.) January 21st, 1895, Shipley water.	4.9	1.02	1.0	2.5	2.5	3.0	3.0	2.40
	(b.) The same water after downward filtration through 50 c.c. marble (pea size) in burette ( $\frac{1}{4}$ " dia- meter) at rate of 5 minutes per 50 c.c.	6.0	Neutral	0.0	0.0	0.0	0.0	0.0	0.00

TABLE CXI.

Showing the EFFECT, as regards PLUMBIC-SOLVENCY, of the FILTRATION of certain ACID MOORLAND WATERS through CHALK.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment	Description of the Experiment.	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) September 4th, 1894, Mossley water.	2.8	0.36	0.1	0.3	0.6	0.7	0.8	0.50
	(b.) The same water after upward filtration through 50 c.c. chalk (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 4 minutes per 50 c.c.	8.4	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
2	(a.) October 18th, 1894, Shipley water.	4.9	0.90	1.0	3.0	3.0	3.0	4.0	2.80
	(b.) The same water after upward filtration through 50 c.c. chalk (bean size) in burette ( $\frac{1}{2}$ " diameter) at rate of 40 seconds per 50 c.c.	6.4	0.48	0.0	0.0	0.5	1.0	1.0	0.50

TABLE CXII.

Showing the EFFECT as regards PLUMBO-SOLVENCY of the FILTRATION of certain ACID MOORLAND WATERS through FLINT.

[The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 minutes per 50 c.c.]

Experiment.	Description of the Experiment	Hardness $\text{CaCO}_3$ parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	(a.) January 21st, 1895, Shipley water.	4.9	1.02	1.0	2.5	2.5	3.0	3.0	2.40
	(b.) The same water after downward filtration through 50 c.c. flint (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 1 minute 40 seconds per 50 c.c.	4.9	0.84	1.0	2.5	3.0	3.0	3.0	2.50
2	(a.) January 29th, 1895, Shipley water.	5.4	0.98	1.0	2.5	2.5	2.5	2.5	2.20
	(b.) The same water after downward filtration through 50 c.c. flint (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 10½ minutes per 50 c.c.	5.4	0.84	1.0	2.0	2.5	2.5	3.0	2.20
3	(a.) January 31st, 1895, Higher Swinshaw water.	3.4	0.48	0.2	1.0	1.2	1.2	1.2	0.96
	(b.) The same water after downward filtration through 50 c.c. flint (pea size) in burette ( $\frac{1}{2}$ " diameter) at rate of 7½ minutes per 50 c.c.	3.2	0.42	0.4	1.2	1.0	1.0	1.0	0.92

The numerous results placed on record in the above tables (Tables CIV. to CXII., both inclusive) may be briefly summed up as follows:—Filtration respectively through asbestos and flint was of negative value, both as regards removal of acidity and plumbo-solvency. Coke and polarite filtration were of relative value only, but the polarite gave better results than the coke, and in the earlier experiments proved quite satisfactory. Iceland Spar, limestone, marble, and chalk were completely satisfactory except when the filtration was too rapid to allow of complete neutralisation of the water. River sand, and especially sea sand, filtration, proved quite satisfactory, both as regards neutralising the acidity and removing the plumbo-solvent ability of the waters; but sandstone sand and sea sand previously treated with hydrochloric acid were of negative or merely relative value. In those cases, in which the filtration experiments were satisfactory, the water was usually rendered "harder."

In the table (CXIII.), pages 211, 212, the results are shown, as regards hardness, acidity, and action on lead of Shipley water, before and after the addition respectively of 0.1 per cent. of powdered marble, river sand, powdered limestone, powdered chalk, sea sand, Iceland Spar, and powdered flint.

The results as regards the powdered marble, limestone, chalk, sea sand, and Iceland Spar were that the acidity and plumbo-solvent ability of Shipley water were completely removed by this treatment and the "hardness" of the water was increased. The river sand and flint were only of relative value, and the water was rendered *less* "hard" by the treatment. Allusion must also be made to certain parallel experiments as regards the erosive ability of the water before and after similar treatment. The results, in relation to erosion, were satisfactory in the case of the marble, limestone, chalk, and Iceland spar "treatment," most unsatisfactory in the case of the river sand, and unsatisfactory also as regards the sea sand and flint treatment.

Speaking in general terms, the marble, limestone, chalk, and Iceland Spar "treatment" was completely efficacious, the sea sand "treatment" less satisfactory, and the river sand and flint treatment of negative value.

Table CXIV., pages 213, 214, shows the effect, as regards acidity and action on lead, of "treating" an acid moorland water with a neutralising quantity of sodium carbonate, lime, and chalk.

It will be noted that the result in each case was satisfactory; the plumbo-solvent ability of the water being completely removed by the treatment. The lime and chalk rendered the water "harder," the sodium carbonate less "hard." The results were also satisfactory as regards erosion.

In the table on pages 215-219 (Table CXV.) the effect, as regards acidity and plumbo-solvent ability, of filtering Shipley water through limestone, is shown.

TABLE CXIII.

Showing the HARDNESS, ACIDITY, and ACTION ON LEAD OF SHIPLEY WATER before and after the ADDITION of POWDERED MARBLE, RIVER SAND, POWDERED LIMESTONE, POWDERED CHALK, SEA SAND, ICELAND SPAR, and POWDERED FLINT.

Experiment.	Description of Experiment.	Hardness CaCO <sub>3</sub> Parts per 100,000.	Acidity in Terms of c.c. of Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Plumbo-solvency—as tested by Upward Filtration through 50 c.c. washed shot at a uniform Rate of 3 Minutes per 50 c.c. Parts per 100,000.					Total Lead Salt. Parts per 100,000.
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
I.—a.	*Shipley water + 0, December 31st, 1894.	5.2	0.96	1.5	3.0	3.0	3.0	3.0	—
b.	The same water + 0.1 per cent. powdered marble, shaken gently every day for five days, and then carefully siphoned off.	10.7	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. in test tube with clean lead 1 × 1/2". (b.) 5 c.c. + 5 c.c. XXX distilled water. On 13th day no action. Lead removed, and acid added.
c.	The same water + 0.1 per cent. river sand, shaken gently every day for 11 days, and then siphoned off.	4.2	0.6	0.8	1.2	1.6	1.6	1.96	(a.) 10 c.c. in test tube with clean lead 1 × 1/2". (b.) 5 c.c. + 5 c.c. XXX. On seventh day marked action in (a) still more so in (b). Lead removed, and acid added.
II.—a.	Shipley water + 0, January 7th, 1895.	4.9	0.9	1.5	3.0	3.0	3.0	3.7	(a.) 10 c.c. in test tube with clean lead 1 × 1/2". (b.) Same as (a). On ninth day no action. Lead removed, and acid added.
b.	The same water + 0.1 per cent. powdered limestone, shaken gently every day for eight days, and then carefully siphoned off.	10.9	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. in test tube with clean lead 1 × 1/2". (b.) 5 c.c. + 5 c.c. XXX. On tenth day no action in (a). Very slight in (b). Lead removed, and acid added.
c.	The same water + 0.1 per cent. powdered chalk, shaken gently every day for nine days, and then carefully siphoned off.	10.9	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. in test tube with clean lead 1 × 1/2". (b.) 5 c.c. + 5 c.c. XXX. On ninth day no action in (a) or (b). Lead removed, and acid added.

\* Eldwich Reservoir.

† Nith river sand.

TABLE CXIII.—continued.

Experi- ment.	Description of Experiment.	Hard- ness CaCO <sub>3</sub> Parts per 100,000.	Acidity in Terms of c.c. " Na <sub>2</sub> CO <sub>3</sub> 10 to neu- tralise 100 c.c. of the Water.	Plumbo-solvency—as tested by Upward Filtration through 50 c.c. washed Shot at a uniform Rate of 3 Minutes per 50 c.c. Parts per 100,000.					Total Lead Salt. Parts per 100,000.		
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.			
										Average	
III.—c.-	Shipley water + 0, January 14th, 1886.	4.9	0.84	1.5	2.0	2.5	3.0	3.0	2.4	(a.) 10 c.c. in test tube with clean lead 1 × 1/4". (b.) 5 c.c. + 5 c.c. XXX. On fourth day slight action in (a). Marked action in (b). Lead removed, and acid added.	(a.) 5.0. (b.) 10.0.
d.-	The same water + 0.1 per cent. "sea sand," shaken gently every day for 10 days, and then carefully siphoned off.	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. in test tube with clean lead 1 × 1/4". (b.) 5 c.c. + 5 c.c. XXX. On eighth day no action in (a). Very marked action in (b), the salt formed falling away from lead on agitation, in large masses. Lead removed, and acid added.	(a.) 0.5. (b.) 15.0.
IV.—a.-	Shipley water + 0, February 4th, 1886.	5.5	0.96	1.0	2.5	3.0	3.0	3.0	2.5	(a.) 10 c.c. in test tube with clean lead 1 × 1/4" On sixth day slight action in (a). Lead removed, and acid added.	(a.) 4.0.
b.-	The same water + 0.1 per cent. powdered Iceland Spar, shaken gently every day for six days, and then care- fully siphoned off.	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. in test tube with clean lead 1 × 1/4". (b.) 5 c.c. + 5 c.c. XXX. On twelfth day no action in (a) or (b). Lead removed, and acid added.	(a.) 0.5. (b.) Trace.
c.-	The same water + 0.1 per cent. powdered flint, shaken gently every day for 12 days, and then carefully siphoned off.	4.9	0.78	0.5	1.0	1.5	1.5	1.5	1.2	(a.) 10 c.c. in test tube with clean lead 1 × 1/4". (b.) 5 c.c. + 5 c.c. XXX. On sixth day no action in (a). Very marked action in (b), the salt formed falling away from lead in large masses on agitation. Lead removed, and acid added.	(a.) 0.5. (b.) 7.5.

\* Cellulose was used.

TABLE CXIV.

Showing the EFFECT, as regards ACIDITY and ACTION on LEAD, of treating an ACID MOORLAND WATER with a neutralising Quantity of SODIUM CARBONATE ( $\text{Na}_2\text{CO}_3$ ), LIME ( $\text{CaO}$ ), and CHALK ( $\text{CaCO}_3$ ). The amount of  $\text{Na}_2\text{CO}_3$  needed exactly to neutralise was found by titrating 100 c.c. of the Water with  $\frac{1}{10}$   $\text{Na}_2\text{CO}_3$ , Phenol-phthalein being used as Indicator. The amount of  $\text{CaO}$  and  $\text{CaCO}_3$  necessary to neutralise was calculated from the result obtained with  $\text{Na}_2\text{CO}_3$ .

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Hard- ness $\text{CaCO}_3$ Parts per 100,000.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot, at the rate of 5 mins. per 50 c.c.					"Erosion" Experiments.	
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
1	2000 c.c. Shipley water +0 in a stoppered Winchester quart bottle shaken daily from October 25th to November 14th, 1895, and then the water carefully siphoned off and tested for acidity, hardness, and action on lead.	Acid	0.90	3.5	1.0	1.0	1.5	1.5	1.5	1.3	(a.) 10 c.c. water in test tube, with strip bright sheet lead $1 \times \frac{1}{4}$ ", November 14th, 1895. (b.) Same as (a). November 15th, 1895. No apparent action in (a). (b.), so lead renewed in (b). November 23rd, 1895. Distinct action now in (a). (b.). Lead removed, acid added, and amount of lead in tubes estimated. (a.) = 20 parts per 100,000. (b.) = 25 parts per 100,000.
2	Same as Experiment 1, but $\text{Na}_2\text{CO}_3$ (enough to neutralise) first added to the water.	Neutral	Neutral	2.7	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. water in test tube, with strip bright sheet lead $1 \times \frac{1}{4}$ ", November 14th, 1895. (b.) Same as (a). Lead renewed in (b). November 16th, 17th, 18th, 19th, 20th, 21st, 22nd. No action, however, visible either in (a) or (b). November 23rd, 1895, lead removed, acid added, and amount of lead in tubes estimated. (a.) = 0.0 parts per 100,000. (b.) = 0.0 parts per 100,000.



TABLE CXIV.—continued.

Experiment.	Description of the Experiment.	Reaction with Lacomoid.	Acidity in Terms of c.c. of $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Hardness $\text{CaCO}_3$ Parts Per 100,000.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot, at the rate of 3 mins. per 50 c.c.					Average.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
3	Same as Experiment 1, but a neutralising quantity of $\text{CaO}$ first added to the water.	Neutral	Neutral	5.2	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. water in test tube, with strip bright sheet lead $1 \times \frac{1}{4}$ ", November 14th, 1895. (b.) Same as (a). As no action took place the lead was renewed in (b) November 16th, 17th, 18th, 19th, 20th, 21st, 22nd. November 23rd, still no action visible, so lead removed, and amount of lead in tubes estimated. (a.) = 0.5 parts per 100,000. (b.) = 0.5 parts per 100,000.
4	Same as Experiment 1, but a neutralising quantity of $\text{CaCO}_3$ first added to the water.	Neutral	Neutral	5.3	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. water in test tube, with strip bright sheet lead $1 \times \frac{1}{4}$ ", November 14th. (b.) Same as (a). As no action took place the lead was renewed in (b) November 16th, 17th, 18th, 19th, 20th, 21st, 22nd. November 23rd, still no action visible, so lead removed, and amount of lead in tubes estimated. (a.) = 0.5 parts per 100,000. (b.) = 0.5 parts per 100,000.

TABLE CXV.

Showing the Effect, as regards ACIDITY and PLUMBO-SOLVENT ABILITY, of filtering SHIPLEY WATER (an Acid Moorland Water) through LIMESTONE.

Experiment.	Description of the Experiment.	Amount of Shipley Water filtered through the Limestone.	Reaction with Lactmold.	Acidity in Terms of c.c. 10% Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1	Control experiment. Shipley water not "treated."	c.c. —	Acid	0.90	1.5	1.5	1.5	1.5	1.5	Experiment 1 is to be considered as the control experiment to Experiments 2 and 3.
2	Shipley water filtered (downwards) through 25 c.c. limestone (pea size) in burette ( $\frac{1}{4}$ in. diameter), and then through asbestos filter. After filtration water tested for acidity and plumbosolvent ability. Experiment started March 18th, 1886.									
	March 19th, 1886	1,000	Neutral	0.12	0.0	0.0	0.0	0.0	0.00	*The burette was partially blocked at its lower end, thus preventing the water from flowing freely away.
	" 20th "	1,000	Acid	0.36	0.0	0.1	0.2	0.2	0.14	
	" 21st "	1,300	"	0.48	0.4	0.5	0.6	0.7	0.58	
	" 22nd "	950	V. ft. acid	*0.18	0.0	0.1	0.1	0.1	0.08	
	" 23rd "	1,300	"	*0.18	0.0	0.1	0.1	0.1	0.1	
	" 24th "	1,000	Neutral	*0.13	0.0	0.0	0.0	0.0	0.00	

TABLE (XV).—continued.

Experiment.	Description of the Experiment.	Amount of Shipley Water filtered through the Limestone.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water	Action on Lead (Results stated as Parts per 100,000).					Remarks.
					The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
2—cont	March 25th, 1896	c.c. 1,000	Acid	0.42	0.1	0.1	0.2	0.2	0.3	0.18
	" 26th "	700	"	0.54	0.2	0.5	0.6	0.6	0.6	0.50
	" 27th "	900	"	0.66	0.6	1.0	1.0	1.0	1.0	0.92
	" 28th "	1,000	"	0.66	0.4	1.0	1.0	1.0	1.0	0.88
	" 29th "	900	"	0.54	0.2	0.8	1.0	1.0	0.8	0.76
	" 30th "	500	"	0.54	0.4	0.8	1.0	1.0	1.0	0.84
	" 31st "	700	"	0.42	0.2	0.4	0.6	0.6	0.6	0.48
	April 1st "	700	"	0.48	0.4	0.6	0.6	0.6	0.6	0.56
	" 2nd "	500	"	0.48	0.4	0.6	0.6	0.6	0.8	0.60
	" 3rd "	600	"	0.60	0.4	0.8	1.0	1.0	0.8	0.80
	" 4th "	700	"	0.66	0.4	0.8	0.8	1.0	1.0	0.80
	" 5th "	1,500	"	0.72	0.6	1.2	1.4	1.4	1.4	1.20
	" 6th "	700	"	0.66	0.4	0.8	1.0	1.0	1.2	0.88
	" 7th "	1,000	"	0.66	0.4	0.8	1.0	1.0	1.0	0.84
	" 8th "	850	"	0.30	0.4	0.3	0.4	0.4	0.4	0.34
	" 9th "	700	"	0.36	0.4	0.6	0.7	0.7	0.7	0.62
	" 10th "	600	"	0.48	0.4	0.6	0.7	0.7	0.7	0.62

Experiments detailed elsewhere (see Table CV.) show that filtration of an acid water through asbestos does not affect, to any appreciable extent, the acidity and plumbo-solvent ability of that water. The asbestos filter was placed, in Experiment 2, at the distal end of the filter, so as to obtain a true comparison with the results obtained in Experiment 3, where the asbestos filter was placed at the proximal end of the limestone filter. It was anticipated that, in Experiment 2, the limestone would become coated with vegetable matter, and so cease to "correct" the water as regards acidity and plumbo-solvent ability, and that in Experiment 3 the asbestos filter would arrest the vegetable matter, and so enable the limestone to neutralise the acidity and plumbo-solvent ability of the water. During the progress of Experiment 2 the limestone accumulated on its surface a large amount of slimy yellowish brown coloured vegetable matter.

[illegible]

TABLE CXV.—continued.

Experiment.	Description of the Experiment.	Amount of Shipley Water filtered through the Limestone.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
3— cont.	May 13th, 1896	c.c.	Neutral	Neutral	0.0	0.0	0.0	0.0	0.0	0.00
	" 14th "	350	"	"	0.0	0.0	0.0	0.0	0.0	0.00
	" 15th "	450	"	"	0.0	0.	0.0	0.0	0.0	0.00
	" 16th "	400	"	"	0.0	0.0	0.0	0.0	0.0	0.00
	" 17th "	725	Pt. acid	0.18	0.1	0.2	0.2	0.2	0.2	0.18
	" 18th "	725	"	0.18	0.1	0.3	0.2	0.3	0.3	0.23
	" 19th "	600	? trace acid	? trace acid			? traces.			
	" 20th "	550	Trace acid	0.18	0.1	0.1	0.1	0.1	0.1	0.10
	" 21st "	400	Neutral	Neutral	0.0	0.0	0.0	0.0	0.0	0.0
	" 22nd "	550	"	"	0.0	0.0	0.0	0.0	0.0	0.0
	" 23rd "	650	V. ft. acid	0.16			? traces.			
	" 24th "	450	Neutral	Neutral	0.0	0.0	0.0	0.0	0.0	0.0
	" 25th "	410	"	"	0.0	0.0	0.0	0.0	0.0	0.0
	" 26th "	380	"	"	0.0	0.0	0.0	0.0	0.0	0.0
	" 27th "	1,000	Acid	0.30	0.1	0.2	0.2	0.3	0.3	0.22
	" 28th "	1,050	"	0.30	0.1	0.2	0.3	0.3	0.3	0.24
	" 29th "	80	Neutral	Neutral	0.0	0.0	0.0	0.0	0.0	0.00



It is to be noted that Experiment 1 shows the acidity and plumbo-solvent ability of the untreated Shipley water, and is to be regarded as the control experiment to Experiments 2 and 3.

In Experiment 2 the water was first filtered through a limestone and then through an asbestos filter. In Experiment 3 the water was first filtered through the asbestos filter and then through the limestone. The distinction is important; and the experiments were designed to show that, unless the suspended vegetable matter in a moorland water is first removed by some mechanical means, the limestone speedily becomes coated with a slimy substance which prevents the water from becoming neutralised.

The results shown in Experiment 2 clearly proved that the limestone soon became coated with vegetable matter, and ceased to correct the acidity, and thereby the plumbo-solvent ability of the water.

Experiment 3 yielded much more satisfactory results, as the filtered water was usually neutral, or only faintly acid, and had either no plumbo-solvent ability or a greatly reduced solvent action on lead. But even in this experiment the vegetable matter seemed to some extent to have passed through the asbestos filter and to have coated the limestone.

The above experiments have a practical bearing on the procedure adopted at different waterworks for the purpose of correcting the acidity and plumbo-solvency of moorland waters. On some waterworks a rough permeable dam composed of limestone or chalk blocks is built across the streams "feeding" the storage reservoirs, near the point where these streams enter the reservoirs. The object of this is to neutralise the acidity of the water as it filters through the blocks. But in a very short space of time the blocks composing the dam become so coated with vegetable matter as to render them useless for the purpose (compare with Experiment 2). On other waterworks the reservoir water is filtered through filters composed of sand, pebbles, and limestone. In such a case the sand mechanically holds back the suspended vegetable matter, and the surface of the limestone remaining clean and uncoated is able continuously to exert a neutralising effect (compare with Experiment 3).

#### Summary (under Section II. (c)).

The experiments described in the foregoing tables are so numerous that it is difficult to summarise the results in a brief, yet intelligible, manner. Such summary as is here attempted should be interpreted with the aid of the detailed descriptions which have preceded it.

Substances, Conditions, or Factors which do not seem to Influence <i>Materially</i> the Question of Acidity and Plumbo-solvency, or which at best can only be regarded as of Relative Value.	Substances, Conditions, or Factors which may Increase the Plumbo-solvent Ability of Moorland Waters.	Substances, Conditions, or Factors which remove the Plumbo solvent Ability of Moorland Waters.
<p>Magnesium sulphate { In the Calcium            pro- Sodium chloride " portion Ammonium chloride " of 0.1                                   per cent.</p> <p>Storing moorland waters in partially filled and un-stoppered bottles for long periods.</p> <p>Boiling (as regards some waters, at all events).</p> <p>Aeration.</p>	<p>Potassium nitrate { To some Sodium            extent Ammonium "        seem-                           ingly.</p> <p>Concentration by boiling (with some waters, at all events).</p> <p>[? Temperature and duration of contact, within certain limits.]</p>	<p>Ammonium car- bonate        - Sodium carbonate Lime water   - Limestone water Calcium phosphate Sodium        "        }</p> <p>If present in amount sufficient to neutralise the water.</p> <p>Shaking with excess of powdered chalk, marble, Iceland Spar, limestone, and some kinds of sand        }</p> <p>By neutralising the acidity.</p>

Substances, Conditions, or Factors which do not seem to Influence *Materially* the Question of Acidity and Plumbo-solvency, or which at best can only be regarded as of Relative Value.

Shaking with flint, silica, and some kinds of sand.

Filtration through asbestos, coke, polarite, flint, and some kinds of sand.

"Coated" lead.

Substances, Conditions, or Factors which may Increase the Plumbo-solvent Ability of Moorland Waters.

Substances, Conditions, or Factors which remove the Plumbo-solvent Ability of Moorland Waters.

Filtration through Iceland Spar, marble, lime-stone, chalk, and some kinds of sand. } By neutralising the acidity.

[Potassium silicate and sodium nitrate inhibited plumbo-solvency, but the samples employed were alkaline in reaction and neutralised the acidity.]

The continuous passage of an acid moorland water through the same lead shot does not result in the water, at the close of the experiment, dissolving less lead than in the earlier stages of the experiment.

The repeated filtration through the same lead shot of the same sample of moorland water does not result in the water dissolving more and more lead as the filtration is again and again repeated.

Lastly, the tendency or the reverse of moorland waters to dissolve lead and the circumstances which govern the vigour of such solvent action of moorland water on lead, were found throughout the experiments to depend solely on the presence of acidity or absence of acidity, and on the degree of acidity of the various waters.

In conclusion, the correlation of acidity and lead-dissolving property and the broad parallelism between the amount of acidity and the vigour of solvent action on lead must, on the basis of the records given in Volume I. and the foregoing experiments, be finally accepted as established facts.

#### (d.) *Natural Waters other than Rain or Moorland Waters.*

No special experiments were carried out under this heading for the obvious reason that the investigation of the negative side of the question of plumbo-solvency was sufficiently covered by the examination of multiple samples of moorland spring waters and moorland "treated" waters. These results have already been given in Volume I., and it only remains to be said that the moorland spring water and the moorland "treated" water (when the treatment was efficacious) were always found to be neutral and free from appreciable solvent action on lead.



### SECTION III.—THE CAUSE OF ACIDITY OF MOORLAND WATERS.

In illustration of the general scope and nature of this section of the enquiry it is of advantage to quote at some length from Mr. Power's report,\* as follows:—

"In proceeding to search for the source or sources of acidity of moorland waters, it appeared first of all important to determine the stage in its moorland history at which a water acquires acidity; whether, for instance, as regards water accumulated in pools in the peat, acidity is, so to speak, manufactured in the water *in situ*, or has been already contributed to it in the process of its passage there. Dr. Houston, therefore, instituted additional laboratory experiments in the following directions.

"Acid waters from several separate moorland gathering grounds were tested as to the amount of acidity possessed by each immediately on collection, and were tested again in like manner after being dealt with in each instance in various ways:—

- (a.) After *boiling*;
- (b.) After *aeration*;
- (c.) After keeping for different periods of time in bottles *completely filled and stoppered*;
- (d.) After keeping for different periods of time in bottles *partially filled and not stoppered*;
- (e.) After neutralising with sodium carbonate; thenceforward retaining, for different periods of time, sections of such sample in bottles *partially filled and completely stoppered*; in bottles *partially filled and not stoppered*; and in bottles *completely filled and completely stoppered*.

"As a result, Dr. Houston found that—

"*Boiling* usually greatly reduced the initial acidity. But certain waters were practically unaffected in this respect by boiling; indeed, sustained boiling of them increased their acidity to an extent corresponding to the concentration of the water.

"*Aeration* usually slightly reduced the initial acidity. But some waters were altogether unaffected as regards their acidity by this process.

"*Keeping in bottles completely filled and completely stoppered* in no instance gave rise to increase of acidity, usually there was slight diminution of that originally observed.

"*Keeping in partially filled bottles not stoppered* usually diminished the acidity very greatly, and in some waters it almost disappeared. But there were waters in which the diminution of acidity was only slight after a considerable lapse of time.

"*Neutralising with sodium carbonate, with subsequent retention of the samples under different conditions of exposure to air*: in no instance was there any redevelopment of acidity.

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\* Report of the Medical Officer, Local Government Board, 1893-94. Lead Poisoning by Moorland Waters. By W. H. Power, F.R.S.

"These observations appeared, all of them, to tend in one direction only. They seemed to indicate that, so far as acidity is concerned, the chemical history of the rain which after falling on a moorland accumulates in depressions on the surface of the peat, is practically complete by the time that it has accumulated there; and that thenceforward such water is little likely *by processes set up within it*, to develop increase of acidity. The question, therefore, arose: What are the conditions to which rainfall on peat moorland is subjected, *antecedent* to its accumulations in pools there, that may be thought of as contributing acid quality to moorland water?

"That *a something* is contributed by peat to water in sustained contact with it, or flowing over it or through it, had indeed been suggested by certain facts noted in regard of the Burnmoor series of observations; and, as a consequence, Dr. Houston had already commenced a week-by-week examination, chemical and bacteriological, of samples of *peat soil* selected by him on certain moorland gathering grounds. This peat soil he had, on a number of different gathering grounds, found to be, where moist, invariably acid. It occurred to him, therefore, at this juncture, to further test his moorland waters the chemical history of which appeared complete, by bringing them once again into relation with the moorland, in so far as this might be done by means of a certain "peat essence" prepared by him for this purpose. And this he accomplished as follows:—

1. By adding, always in minute amount, freshly collected samples of acid moorland waters to sterile (neutral) peat decoction.
2. By adding, in small amount, sterile (neutral) peat decoction to freshly-collected samples of acid moorland water.

"The result was, to say the least, interesting. The neutral peat decoction, to which moorland water had been added, showed signs of bacterial growth, and developed in most instances acid reaction. So, too, the moorland waters, to which peat decoction had been added, showed signs of bacterial growth, and usually increased in acidity. Thus, it was seen that if the agency dominant in producing the acid in question was contained in the *sterile* peat decoction, this agent must needs be of chemical not of biological nature; whereas, if contained in the moorland waters, it might be the one or the other. Hence followed the inference that failure of moorland waters under laboratory conditions to increase their acidity was due to the circumstance that they had become divorced from the peat; with the further suggestion, namely, that moorland water samples are apt to contain bacteria—no doubt derived from the peat—capable of generating acid when brought in relation with sterile peat decoction.

"In these circumstances Dr. Houston instituted additional experiments in which, for the purpose of inhibiting bacterial processes in acid moorland water samples, alcohol as well as sterile peat decoction was added thereto. And he found that in every instance the water thus dealt with failed to develop additional acidity. With this indication that biological considerations were very possibly involved in satisfactory solution of the problem of acidity of moorland waters, Dr. Houston reverted somewhat hopefully to his study of the bacterial constituents of peat soil. His results, so far, in this connection are briefly as follows:—

"To separate samples of *distilled water* that was neutral in its reaction and which did not dissolve lead, there were added small

amounts in each instance of *moist peat soil* from different selected gathering grounds. As a result every sample of distilled water developed in a short while acid reaction and was found to have acquired ability to dissolve lead.

"To separate samples of *sterile (neutral) peat decoction* which did not dissolve lead, there were added minute amounts in each instance of *moist peat soil* from different gathering grounds. As a result the samples of peat decoction always developed bacterial growth, and at the same time were usually found to possess acid reaction and ability to dissolve lead.

"Gelatine plates inoculated with material from the above peat decoctions that had become acid as a result of addition to them of minute amounts of peat soil developed colonies of a variety of microbes.

"Separated in pure culture and severally retransferred to other samples of sterile (neutral) peat decoction, the *majority* of the microbes that had been isolated failed to render this culture medium acid, or to confer on it ability to dissolve lead.

"A *minority*, two in number, of the microbes thus isolated in pure culture *did*, when retransferred to sterile (neutral) peat decoction, render this medium acid, and they conferred on it at the same time ability to dissolve lead. Provisionally, Dr. Houston designates these microbes 'O' and 'Q.'

"*Moist peat soil* from a variety of gathering grounds, when subjected to the process of plate culture, yielded—

- (a.) A number of microbes which, when inoculated in pure culture into sterile (neutral) peat decoction, either did not grow therein; or, if they grew, produced no acid change in the medium.
- (b.) Two microbes which, when inoculated into sterile (neutral) peat decoction, multiplied therein with considerable vigour, produced in the medium acid reaction, and conferred on it ability to dissolve lead.

These two microbes, which were found to be identical with 'O' and 'Q' above referred to, are still subjects of study by Dr. Houston."

#### A.—CHEMICAL EXPERIMENTS.

The following tables (Tables CXVI., CXVII., and CXVIII.) deal with the acidity of Shipley, Mossley, and Settle Peat Pool waters, (a) in completely filled and stoppered bottle and (b) in incompletely filled and unstoppered bottles :—

TABLE CXVI.

Showing the AMOUNT of the ACIDITY in SHIPLEY WATER (SURFACE of ELWDICK RESERVOIR), and the EFFECT, as regards ACIDITY, of preserving the WATER for some time—(a) in COMPLETELY FILLED and STOPPERED BOTTLES and (b) in INCOMPLETELY FILLED and UNSTOPPERED BOTTLES.

Experiment.	Description of the Experiment.	Results stated as c.c. $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> needed to neutralise 100 c.c. of the Water.				
		A.	B.	C.	Per-centage Reduction of Acidity.	
		Original Acidity.	Acidity after being kept for some time in completely Filled and Stoppered Bottles.	Acidity after being kept for some time in partially Filled and Unstoppered Bottles.	B. from A.	C. from A.
1	ShipleY water : A. tested February 2, 1894. B. C. tested February 24, 1894 (22 days).	1·3	1·30	1·20	0	7
2	ShipleY water : A. tested February 27, 1894. B. C. tested March 23, 1894 (23 days).	1·0	1·00	1·00	0	0
3	ShipleY water : A. tested March 5, 1894. B. C. tested April 13, 1894 (39 days).	1·08	0·96	0·84	11	22
4	ShipleY water : A. tested March 13, 1894. B. C. tested April 13, 1894 (31 days).	1·15	1·0	0·96	0	17
5	ShipleY water : A. tested March 20, 1894. B. C. tested April 13, 1894 (24 days).	0·9	0·84	0·72	6	20
6	ShipleY water : A. tested May 29, 1894. B. C. tested June 16, 1894 (18 days).	1·2	1·20	1·20	0	0
7	ShipleY water : A. tested June 4, 1894. B. C. tested June 25, 1894 (21 days).	1·3	1·30	1·20	0	7
8	ShipleY water : A. tested June 11, 1894. B. C. tested June 25, 1894 (14 days).	1·2	1·20	1·10	0	8
9	ShipleY water : A. tested June 18, 1894. B. C. tested July 18, 1894 (30 days).	1·08	0·96	0·96	11	11
10	ShipleY water : A. tested June 25, 1894. B. C. tested July 18, 1894 (23 days).	1·08	1·08	0·96	0	11

From the foregoing table it appears that ShipleY water, when preserved for some time in partially filled and unstoppered bottles, lost as a rule a slight amount of its original acidity; but, when kept in completely filled and stoppered bottles, the water usually retained its original acidity in full degree.

TABLE CXVII.

Showing the AMOUNT of the ACIDITY of the MOSSLEY MAIN WATER and the EFFECT as regards ACIDITY of preserving the WATER (a) in COMPLETELY FILLED and STOPPERED BOTTLES and (b) in INCOMPLETELY FILLED and UNSTOPPERED BOTTLES.

Experiment.	Description of the Experiment.	Results stated as c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.				
		A.	B.	C.	Per-centage Reduction of Acidity.	
		Original Acidity.	Acidity after being kept for some time in completely Filled and Stoppered Bottles.	Acidity after being kept for some time in partially Filled and Unstoppered Bottles.	B. from A.	C. from A.
1	Mossley main water: A. tested January 2, 1894. B. C. tested February 3, 1894 (32 days).	0.30	0.30	0.30	0	0
2	Mossley main water: A. tested January 10, 1894. B. C. tested February 5, 1894 (26 days).	0.36	0.36	0.24	0	33
3	Mossley main water: A. tested January 18, 1894. B. C. tested January 29, 1894 (11 days).	0.30	0.24	0.24	20	20
4	Mossley main water: A. tested January 26, 1894. B. C. tested February 7, 1894 (12 days).	0.30	0.24	0.24	20	20
5	Mossley main water: A. tested February 1, 1894. B. C. tested February 28, 1894 (27 days).	0.30	0.24	0.20	20	33
6	Mossley main water: A. tested February 16, 1894. B. C. tested March 23, 1894 (35 days).	0.36	0.36	0.30	0	16
7	Mossley main water: A. tested March 6, 1894. B. C. tested April 13, 1894 (38 days).	0.36	0.36	0.24	0	33
8	Mossley main water: A. tested March 10, 1894. B. C. tested April 13, 1894 (34 days).	0.36	0.36	0.30	0	16
9	Mossley main water: A. tested March 22, 1894. B. C. tested April 13, 1894 (22 days).	0.30	0.30	0.24	0	20
10	Mossley main water: A. tested June 12, 1894. B. C. tested June 27, 1894 (15 days).	0.54	0.48	0.30	11	44
11	Mossley main water: A. tested June 19, 1894. B. C. tested July 18, 1894 (29 days).	0.48	0.48	0.36	0	25
12	Mossley main water: A. tested June 27, 1894. B. C. tested July 18 (21 days).	0.54	0.54	0.36	0	33

The results obtained with Mossley water were very similar to those obtained with Shipley water; but, on the whole, Mossley water showed a greater tendency to lose acidity on keeping than Shipley water.

TABLE CXVIII.

Showing the AMOUNT of the ACIDITY in SETTLE PEAT POOL WATER, and the EFFECT as regards ACIDITY of keeping the WATER for some time—(a) in COMPLETELY FILLED and STOPPERED BOTTLES and (b) in INCOMPLETELY FILLED and UNSTOPPERED BOTTLES.

Experiment.	Description of the Experiment.	Results stated as c.c. $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.				
		A.	B.	C.	Per-centage Reduction of Acidity.	
		Original Acidity.	Acidity after being kept for some time in completely Filled and Stoppered Bottles.	Acidity after being kept for some time in partially Filled and Unstoppered Bottles.	B. from A.	C. from A.
1	Settle Peat Pool: A. tested January 19, 1894; B., C. tested February 3, 1894 (15 days).	0.48	0.48	0.36	0	25
2	Settle Peat Pool: A. tested January 22, 1894; B., C. tested February 5, 1894 (14 days).	0.96	0.96	0.60	0	37.5
3	Settle Peat Pool: A. tested January 23, 1894; B., C. tested February 5, 1894 (13 days).	1.30	1.08	0.60	17	54
4	Settle Peat Pool: A. tested January 25, 1894; B., C. tested February 7, 1894 (13 days).	0.48	0.48	0.24	0	50
5	Settle Peat Pool: A. tested January 29, 1894; B., C. tested February 10, 1894 (12 days).	1.08	0.96	0.72	11	33
6	Settle Peat Pool: A. tested January 30, 1894; B., C. tested February 10, 1894 (11 days).	0.48	0.42	0.36	12	25
7	Settle Peat Pool: A. tested February 3, 1894; B., C. tested February 12, 1894 (9 days).	0.36	0.30	0.24	16	33
8	Settle Peat Pool: A. tested February 5, 1894; B., C. tested February 11, 1894 (6 days).	0.36	0.36	0.24	0	33
9	Settle Peat Pool: A. tested February 8, 1894; B., C. tested February 23, 1894 (15 days).	0.36	0.36	0.30	0	16

TABLE CXVIII.—*continued.*

Experiment.	Description of the Experiment.	Results stated as c.c. $\frac{25}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.				
		A.	B.	C.	Per-centage Reduction of Acidity.	
		Original Acidity.	Acidity after being kept for some time in completely Filled and Stopped Bottles.	Acidity after being kept for some time in partially Filled and Unstoppered Bottles.	B. from A.	C. from A.
10	Settle Peat Pool: A. tested February 4, 1894; B., C. tested February 24, 1894 (10 days).	0·84	0·84	0·48	0	43
11	Settle Peat Pool: A. tested February 24, 1894; B., C. tested February 28, 1894 (4 days).	0·60	0·60	0·43	0	20
12	Settle Peat Pool: A. tested February 22, 1894; B., C. tested February 28, 1894 (6 days).	0·60	0·60	0·43	0	20
13	Settle Peat Pool: A. tested March 2, 1894; B., C. tested March 8, 1894 (6 days).	0·60	0·54	0·48	10	20
14	Settle Peat Pool: A. tested March 9, 1894; B., C. tested March 13, 1894 (9 days).	0·60	0·60	0·36	0	40
15	Settle Peat Pool: A. tested March 19, 1894; B., C. tested March 31, 1894 (12 days).	0·66	0·66	0·24	0	63
16	Settle Peat Pool: A. tested June 5, 1894; B., C. tested June 9, 1894 (4 days).	0·48	0·48	0·30	0	37

Settle Peat Pool water usually lost none, or only very little, of its original acidity when kept in completely filled and stoppered bottles; but, when preserved in partially filled and unstoppered bottles, a distinctly appreciable loss of acidity usually occurred.

The results, as a whole, seem to indicate that the storage of acid moorland waters (*e.g.*, in reservoirs) could certainly not be relied on to remove the acidity, but that storage would probably be of some benefit in that it might reduce to some extent the degree of acidity, and doubtless also to a corresponding extent the degree of plumbo-solvent ability. In none of the experiments was any appreciable gain in the amount of acidity observed.

The above results receive confirmation from those set forth in Table CXIX.

TABLE CXIX.

wing the RESULTS, as regards ACIDITY, of keeping certain MOORLAND WATERS for varying PERIODS of TIME in COMPLETELY FILLED and STOPPERED BOTTLES and in BOTTLES only PARTIALLY FILLED and UNSTOPPERED.

Description of the Sample Water.	Reaction with Lacmoid.			Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.			Date of commencement of Experiment and date of subsequent Testing for Acidity.
	Reaction of the Water when first examined.	Reaction of the Water after being kept for some Time in completely filled and stoppered Bottle.	Reaction of the Water after being kept for some Time in a Bottle only partially filled and unstoppered.	Acidity of the Water when first examined.	Acidity of the Water after being kept for some Time in completely filled and stoppered Bottle.	Acidity of the Water after being kept for some Time in a Bottle only partially filled and unstoppered.	
Corn Brook Reservoir water (Rochdale Waterworks).	Acid	Acid	Trace acid.	0.30	0.30	0.12	March 4th to April 3rd, 1896.
Wham Reservoir water (Rochdale Waterworks).	"	"	? neutral	0.36	0.36	0.12	March 4th to April 3rd, 1896.
Sample of "iron" water from coal workings on Rochdale gathering ground. This water at one time was allowed to enter waterworks. The acidity appears to be due to the oxidation of iron pyrites ( $\text{FeS}_2$ ) which is present in the workings in great quantity.	—	"	Acid	—	8.40	3.60	March 9th to April 3rd, 1896.
Feeder (North side) to Langden Brook (Preston Waterworks).	Acid	"	Trace acid.	0.36	0.36	0.24	March 11th to April 3rd, 1896.
Benny Clough intake (Blackburn Waterworks).	"	"	"	0.30	0.36	0.24	March 13th to April 7th, 1896.
Feeder to Well Spring Clough (Blackburn Waterworks).	"	"	"	0.54	0.54	0.30	March 13th to April 7th, 1896.
Spring Reservoir water (Bolton Waterworks).	"	"	"	0.48	0.42	0.30	March 17th to April 13th, 1896.
Cadshaw Brook (Bolton Waterworks).	"	"	"	0.36	0.42	0.30	March 17th to April 13th, 1896.
"Inlet" Ardley Reservoir "before treatment" Wakefield Waterworks.	"	"	"	0.84	0.84	0.72	March 30th to April 13th, 1896.
Sample of "iron" water from coal workings (as in Experiment 3).	"	"	"	7.68	7.92	7.68	March 31st to April 13th, 1896.
Venous Clough No. 1 (Bacup Waterworks).	"	"	"	0.78	0.72	0.60	April 3rd to April 13th, 1896.
Venous Clough No. 2 (Bacup Waterworks).	"	"	"	1.08	1.08	1.02	April 3rd to April 13th, 1896.
"Inlet" Sheephouse Clough Reservoir (Bacup Waterworks).	"	"	"	0.48	0.48	0.24	April 7th to April 13th, 1896.
Sheephouse Clough Reservoir (Bacup Waterworks).	"	"	"	0.66	0.66	0.54	April 3rd to April 13th, 1896.
"Inlet" Blackmoorfoot Reservoir (Huddersfield Waterworks).	"	"	"	0.42	0.42	0.36	April 7th to April 13th, 1896.
"Outlet" Blackmoorfoot Reservoir (Huddersfield Waterworks).	"	"	"	0.66	0.60	0.60	April 7th to April 13th, 1896.
Dunford Bridge Reservoir (Dewsbury and Heckmondwike Waterworks).	"	"	Faint acid.	0.36	0.30	0.18	April 9th to April 14th, 1896.



It will be seen that the general results showed that keeping acid moorland waters in completely filled and stoppered bottles led to little or no loss of the initial acidity, but that when the waters were stored in partially filled and unstoppered bottles an appreciable loss of acidity usually occurred.

The following two tables (CXX. and CXXI.) show the results as regards acidity of boiling Mossley water and of boiling (and also of aerating) Settle Peat Pool water :—

TABLE CXX.

Showing the AMOUNT of the ACIDITY in MOSSLEY MAIN WATER and the EFFECT, as regards ACIDITY, of boiling the WATER for  $\frac{1}{2}$  Hour and making up to the ORIGINAL AMOUNT with a NEUTRAL DISTILLED WATER.

Experiment.	Description of the Sample of Water.	Result stated as c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.		Per-centage of Reduction of Acidity.
		Acidity.	Acidity after Boiling.	
1	Mossley main water, November 2, 1893 -	0.54	0.24	55 per cent.
2	" " " " 10, " -	0.48	0.24	48 "
3	" " " " 16, " -	0.40	0.30	25 "
4	" " " " 20, " -	0.50	0.40	20 "
5	" " " " 27, " -	0.50	0.40	20 "
6	" " " December 4, " -	0.24	0.18	25 "
7	" " " " 9, " -	0.70	0.50	28 "
8	" " " " 14, " -	0.36	0.20	44 "
9	" " " " 20, " -	0.36	0.24	33 "
10	" " " January 2, 1894 -	0.30	0.24	20 "
11	" " " " 10, " -	0.36	0.00	100 "
12	" " " " 18, " -	0.30	0.12	66 "
13	" " " " 26, " -	0.30	0.20	33 "

TABLE CXXI.

Showing the EFFECT as regards ACIDITY (a) of BOILING and (b) AERATION of WATER obtained from "SETTLE PEAT POOL."

Experiment.	Description of the Sample of Water.	Acidity in terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.		
		Natural Acidity.	After raising the Temperature of the Water to Boiling Point.	After aspirating Air through the Water for half hour.
1	Settle Peat Pool water, January 22, 1894 -	0.90	0.60	—
2	" " " January 29, 1894 -	1.08	0.72	0.72
3	" " " January 30, 1894 -	0.45	0.12	0.18

The results in general showed that boiling usually materially reduced, but did not remove, the acidity of Mossley and Settle Peat Pool waters. Aspiration of air through Settle Peat Pool water reduced its acidity to a considerable extent.

In the following table (Table CXXII.) the relation between the amount of the acidity and dissolved oxygen in the water of Settle Peat Pool when stored—(a) in completely filled and stoppered bottles and (b) in partially filled and unstoppered bottles is shown:—

TABLE CXXII.

Showing the RELATION between the AMOUNT of the ACIDITY and DISSOLVED OXYGEN in the WATER of "SETTLE PEAT POOL."

Experiment.	Description of the Experiment.	Dissolved Oxygen.			Acidity.		
		Results stated as Parts per 100,000.			Results stated c.c. $\frac{25}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.		
		A.	B.	C.	D.	E.	F.
		Original Amount.	After being kept for some Time in completely filled and Stoppered Bottles.	After being kept for some Time in partially filled and Unstoppered Bottles.	Original Amount.	After being kept for some Time in completely filled and Stoppered Bottles.	After being kept for some Time in partially filled and Unstoppered Bottles.
1	Settle Peat Pool : A., D., tested January 30, 1894; B., C., E., F., tested February 10, 1894 (11 days).	1.35	1.27	1.22	0.48	0.42	0.36
2	Settle Peat Pool : A., D., tested February 3, 1894; B., C., E., F., tested February 12, 1894 (9 days).	1.24	1.17	1.20	0.36	0.36	0.24
3	Settle Peat Pool : A., D., tested February 6, 1894; B., C., E., F., tested February 11, 1894 (6 days).	1.22	1.17	1.22	0.36	0.36	0.24
4	Settle Peat Pool : A., D., tested February 14, 1894; B., C., E., F., tested February 24, 1894 (10 days).	0.88	0.74	1.26	0.84	0.84	0.48
5	Settle Peat Pool : A., D., tested February 24, 1894; B., C., E., F., tested February 18, 1894 (4 days).	1.19	1.12	1.25	0.60	0.60	0.48

TABLE CXXII.—*continued.*

Experiment.	Description of the Experiment.	Dissolved Oxygen.			Acidity.		
		Results stated as Parts per 100,000.			Results stated c.c. $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.		
		A.	B.	C.	D.	E.	F.
		Original Amount.	After being kept for some Time in completely filled and Stoppered Bottles.	After being kept for some Time in partially filled and Unstoppered Bottles.	Original Amount.	After being kept for some Time in completely filled and Stoppered Bottles.	After being kept for some Time in partially filled and Unstoppered Bottles.
6	Settle Peat Pool: A., D., tested February 28, 1894; B., C., E., F., tested March 6, 1894 (6 days).	1·01	0·94	1·10	0·60	0·60	0·46
7	Settle Peat Pool: A., D., tested March 2, 1894; B., C., E., F., tested March 8, 1894 (6 days).	1·11	0·90	—	0·60	0·54	0·46
8	Settle Peat Pool: A., D., tested March 9, 1894; B., C., E., F., tested March 18, 1894 (9 days).	1·08	1·02	1·13	0·60	0·60	0·36
9	Settle Peat Pool: A., D., tested March 19, 1894; B., C., E., F., tested March 31, 1894 (12 days).	0·98	0·98	1·11	0·66	0·66	0·24
10	Settle Peat Pool: A., D., tested June 6, 1894; B., C., E., F., tested June 9, 1894 (4 days).	1·15	0·98	1·06	0·48	0·48	0·30

The results seem to indicate that, whereas the acidity of the water remained practically unaltered when the water was stored in completely filled and stoppered bottles, the acidity was reduced to a considerable extent when the water was kept in partially filled and unstoppered bottles, the amount of dissolved oxygen being usually slightly reduced under the first set of conditions and, if anything, increased under the latter set of conditions.

The following table (CXXIII.) is important, because it shows the effect, as regards acidity, of keeping certain acid moorland waters, after neutralization with sodium carbonate—(a) in stoppered bottles with an air space, (b) in unstoppered bottles, and (c) in completely filled and stoppered bottles:—

TABLE CXXIII.

Showing the EFFECT, as regards ACIDITY, of keeping certain ACID MOORLAND WATERS, after NEUTRALISATION with SODIUM CARBONATE—(a) in STOPPERED BOTTLES with an AIR SPACE, (b) in UNSTOPPERED BOTTLES, and (c) in COMPLETELY FILLED and STOPPERED BOTTLES.

Experiment.	Description of the Sample of Water.	The Water was neutralised with $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ the Indicator used being	The Water was kept for some Time in	The Reaction of the Water was tested after the lapse of	Remarks.
1	July 3, 1894, Shipley water	Phenol-phthalein.	Stoppered bottle with an air space.	Days. 20	100 c.c. of the water required 0.13 $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ to give pink colour with phenol-phthalein. Neutral reaction with lacmoid.
2	July 4, 1894, Mossley water	"	"	19	" "
3	July 9, 1894, Shipley water	"	"	19	" "
4	July 10, 1894, Mossley water	"	"	18	" "
5	July 16, 1894, Shipley water	"	"	15	" "
6	July 17, 1894, Mossley water	"	"	14	" "
7	July 23, 1894, Shipley water	"	Unstoppered bottle.	16	" "
8	July 24, 1894, Mossley water	"	"	15	" "
9	July 30, 1894, Shipley water	"	"	9	" "
10	July 31, 1894, Mossley water	"	"	8	" "
11	August 6, 1894, Shipley water	"	"	9	" "
12	August 7, 1894, Mossley water	"	"	8	" "
13	November 13, 1894, Shipley water.	Methyl-orange.	Stoppered bottle with an air space.	68	Neutral reaction with methyl-orange and lacmoid.
14	November 15, 1894, Ardsley water.	"	"	60	" "
15	November 20, 1894, Shipley water.	"	"	55	" "
16	November 26, 1894, Shipley water.	"	"	49	" "
17	December 3, 1894, Shipley water.	"	"	43	" "
18	December 10, 1894, Shipley water.	"	"	35	" "
19	December 17, 1894, Shipley water.	"	"	28	" "
20	December 3, 1894, Shipley water.	"	Completely filled and stoppered bottle.	42	" "
21	December 10, 1894, Shipley water.	"	"	35	" "
22	December 17, 1894, Shipley water.	"	"	28	" "

It will be seen that acid moorland waters, after neutralisation with sodium carbonate, do not become acid again, when stored for considerable periods—(a) in stoppered bottles with an air space, (b) in unstoppered bottles and (c) in completely filled and stoppered bottles.

In the following table (CXXIV.) the results, as regards acidity, of the distillation of certain acid moorland waters are shown :—

TABLE CXXIV.

Showing the RESULTS, as regards ACIDITY, of the DISTILLATION of certain ACID MOORLAND WATERS.

Experiment.	Date.	Description of the Experiment.
1	1894. Oct. 23	From 1,000 c.c. of Shipley water 500 c.c. were distilled into 1 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . Alkalinity distillate (500 c.c.) = 1 c.c. $\frac{N}{10}$ $\text{H}_2\text{SO}_4$ . Therefore no loss of alkalinity in distillate. Acidity residue (500 c.c.) = $2.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Acidity 500 c.c. Shipley water = $1.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Therefore no loss of acidity in residue. Methyl-orange used as indicator.
2	Oct. 30	From 1,000 c.c. of Shipley water 500 c.c. were distilled into 1 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . Alkalinity distillate (500 c.c.) = 1 c.c. $\frac{N}{10}$ $\text{H}_2\text{SO}_4$ . Therefore no loss of alkalinity in distillate. Acidity residue (500 c.c.) = $2.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Acidity 500 c.c. Shipley water = $1.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Therefore no loss of acidity in residue. Methyl-orange used as indicator.
3	Nov. 5	From 1,000 c.c. of Shipley water 500 c.c. were distilled into 1 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . Alkalinity distillate (500 c.c.) = 1 c.c. $\frac{N}{10}$ $\text{H}_2\text{SO}_4$ . Therefore no loss of alkalinity in distillate. Acidity residue (500 c.c.) = $2.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Acidity 500 c.c. Shipley water = $1.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Therefore no loss of acidity in residue. Methyl-orange used as indicator.
4	Nov. 8	From 1,000 c.c. of Ringstone Reservoir water 500 c.c. were distilled into 1 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . Alkalinity distillate (500 c.c.) = 1 c.c. $\frac{N}{10}$ $\text{H}_2\text{SO}_4$ . Therefore no loss of alkalinity in distillate. Acidity residue (500 c.c.) = $1.6 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Acidity 500 c.c. Ringstone water = $1.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Therefore loss of acidity in residue. Methyl-orange used as indicator.
5	Nov. 13	Shipley water. Same results as in Experiment 1.
6	Nov. 19	" " " "
7	Nov. 26	From 1,000 c.c. of Shipley water 500 c.c. were distilled into 1 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . Alkalinity distillate (500 c.c.) = 1 c.c. $\frac{N}{10}$ $\text{H}_2\text{SO}_4$ . Therefore no loss of alkalinity in distillate. Acidity residue (500 c.c.) = $1.75 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Acidity 500 c.c. Shipley water = $1.0 \frac{N}{10} \text{Na}_2\text{CO}_3$ . Therefore slight loss of acidity in residue. Methyl-orange used as indicator.

It is to be noted that Shipley water on distillation yielded no appreciable acidity to its distillate, and the residual water was nearly always

as acid as might have been anticipated from the degree of its concentration. Ringstone Reservoir water, on boiling, lost some of its original acidity, but did not yield acid in its distillate.

At this stage, a brief summary of the foregoing results may not be out of place. Both boiling and aerating acid moorland waters usually had the effect of reducing the initial acidity. But some waters were practically unaffected by treatment of this sort. With these waters, indeed, concentration by boiling usually increased their acidity to an extent roughly corresponding to the degree of concentration of the water. Keeping acid moorland waters for differing periods of time—(a) in bottles completely filled and stoppered and (b) in bottles only partially filled and not stoppered, never gave rise to any increase of acidity. Under (a) set of conditions there was usually a slight loss of acidity, but under (b) set of conditions the diminution of the acidity originally observed was much more pronounced. Nevertheless, some waters were not affected, or affected to a hardly appreciable extent, by storage for a considerable period of time, either under (a) or (b) set of conditions.

There was never any re-development of acidity in the case of waters neutralised with sodium carbonate and kept in bottles under different conditions of exposure to air for differing periods of time.

It is convenient in the next place to consider a series of tables dealing with the effect, as regards acidity, of adding to various waters measured quantities of "peat ash," "iron ore," ferrous sulphide, marcasite, iron pyrites, sandstone, and shale.

TABLE CXXV.

Showing the RESULT of certain EXPERIMENTS with PEAT ASH.

Experiment.	Date.	Description of the Experiment.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Filtrate.	Iron.
1	1895. Aug. 21	10 grms. Huddersfield peat ignited in platinum crucible. Residue washed with distilled water (which had previously been boiled, and which was neutral in reaction) and filtered. The filtrate (100 c.c.) was tested for acidity and presence or absence of iron.	Neutral	0.12	No iron in filtrate, but present in large quantity in residue.
2	Sept. 12	20 grms. Halifax peat treated as in Experiment 1.	Neutral	0.12	? Trace of iron in filtrate; abundant in residue.
3	Sept. 20	Same as Experiment 2, but a different sample of Halifax peat.	Neutral	0.12	? Trace of iron in filtrate; abundant in residue.

TABLE CXXVI.

Showing the RESULT, as regards ACIDITY, of the addition of PEAT ASH to certain WATERS.

Experiment.	Description of Experiment.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Filtrate.	Remarks.
I.	January 25th, 1896 :— (a.) 200 c.c. distilled water + 0.1 % Settle peat ash in stoppered bottle with large air space. After one day, siphoned off and tested for acidity. Control experiment. (b.) Same as (a), but 38 days allowed to elapse.	Neutral "	0.12 0.12	The peat was obtained from moorland in the neighbourhood of Settle. The ash was obtained by fully igniting the peat in a platinum crucible.
II.	January 25th, 1896 :— (a.) Same as (a), Experiment I., but rain-water used instead of distilled water. (b.) Same as (a), but 38 days allowed to elapse.	Neutral "	0.12 0.12	
III.	January 25th, 1896 :— (a.) Same as (a), Experiment I., but Shipley water used instead of distilled water. (b.) Same as (a), but 38 days allowed to elapse.	Acid "	0.54 0.54	Shipley water is an example of a moorland water with an acid reaction.

The results show that peat ash is neutral, and that its addition to neutral distilled water and rain-water does not lead to the production of any acidity ; further, that the addition of peat ash to an acid moorland water does not result in any increase of the initial acidity.

In the following table (Table CXXVII.) the results, as regards acidity and plumbo-solvency, of certain experiments with sulphide of iron ( $\text{FeS}$ ) are shown :—

TABLE CXXVII.

Showing the Results, as regards Acidity and Plumbo-solvency, of certain EXPERIMENTS with SULPHIDE of IRON, FeS.

Experiment.	Description of the Experiments.	Reaction with Lacmoid.	Acidity in Terms of $\frac{1}{10} \text{N}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.				
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c. Average.
1a	10 grms. Mossley peat +0, in muslin bag, in 500 c.c. distilled water (previously boiled and found to be neutral and free from plumbo-solvent ability) contained in a stoppered bottle with large air space. October 15th, 1895. Tested October 28th, 1895, for acidity and plumbo-solvent ability.	Acid	0.73	0.1	0.3	0.4	0.5	0.44
1b	Same as 1a, but the peat first mixed with 0.1 grm. powdered iron sulphide, FeS	Acid	0.54	0.0	0.2	0.3	0.3	0.24
2a	50 grms. Mossley peat +0 spread out on a glass dish and kept in a moist chamber with large air space, from October 16th to November 29th, 1895. The peat was then placed in a muslin filter, and 1000 c.c. distilled water (previously boiled, neutral, and free from plumbo-solvent ability) filtered slowly through the peat, and the filtrate tested for acidity and plumbo-solvency.	Acid	0.36	0.1	0.3	0.4	0.5	0.36
2b	Same as 2a, but the peat first mixed with 0.5 grm. powdered iron sulphide, FeS	Acid	0.43	0.3	0.6	0.7	0.8	0.64
3a	50 grms. Mossley peat +0, tied up in a muslin bag, and hung in the open air to oxidise from October 16th to November 28th, 1895. The peat was then placed in a muslin filter and 1,000 c.c. distilled water (previously boiled, neutral, and free from plumbo-solvent ability), filtered slowly through the peat, and the filtrate was tested for acidity and plumbo-solvency.	Acid	0.30	0.2	0.4	0.6	0.7	0.52
3b	Same as 3a, but the peat first mixed with 0.5 grms. powdered iron sulphide, FeS	Acid	0.36	0.3	0.6	0.7	0.7	0.62
4a	200 c.c. distilled water (previously boiled and found to be neutral in reaction) +0, in stoppered bottle with large air space. October 30th, 1895. After 24 hours tested for acidity.	Neutral	0.12	—	—	—	—	—
4b	Same as 4a, but 2 grms. powdered iron sulphide FeS added to the water. Tested after 24 hours, i.e., before oxidation could have taken place.	? Trace acid.	0.18	—	—	—	—	—



TABLE CXXVII.—*continued.*

Experiment.	Description of the Experiments.	Reaction with Lacmoid.	Acidity in Terms of c.c. 10 N <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.				
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c. Average.
5a	200 c.c. distilled water (previously boiled and neutral in reaction) +0, in stoppered bottle, with large air space. October 15th, 1895. Tested October 30th, 1895, for acidity.	Neutral	0·12	—	—	—	—	—
5b	Same as 5a, but 2 grms. iron sulphide added to the water . . . . .	? Trace acid.	0·18	—	—	—	—	—
6a	200 c.c. rain-water +0, in stoppered bottle, with large air space. October 15th, 1895. Tested November 11th, 1895, for acidity.	Neutral	0·12	—	—	—	—	—
6b	Same as 6a, but 2 grms. iron sulphide added to the water . . . . .	? Trace acid.	0·18	—	—	—	—	—
7a	200 cc. Shipley water +0, in stoppered bottle, with large air space. October 15th, 1895. Tested November 19th, 1895, for acidity	Acid	0·60	—	—	—	—	—
7b	Same as 7a, but 2 grms. iron sulphide added to the water . . . . .	Acid	1·08 The end re- action was obscure and difficult to compare with that observed in the case of 7a.	—	—	—	—	—

It will be noted that, under the conditions of experiments specified in the above table, sulphide of iron ( $\text{FeS}$ ) seemed, as regards production of acid, to have no material influence. A very different result, however, was obtained with iron pyrites ( $\text{FeS}_2$ ), as will presently be shown.

Table CXXVIII. shows the effect, as regards acidity, of adding measured quantities of "iron ore" to various waters, and keeping for differing periods of time in stoppered bottles with air space.

TABLE CXXVIII.

Showing the EFFECT, as regards Acidity, of adding IRON ORE to VARIOUS WATERS, and keeping for varying Periods in Stoppered Bottles with Air Space.

[The iron ore was scraped from the surface of the marl (which underlies the peat) in the feeders on the Stipley moorland gathering ground.]

Experiment.	Description of the Experiment.	Water siphoned off after	Acidity—	
			Reaction with Lacmoid.	In Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.
1	June 6th, 1895:— (a.) Boiled distilled water + 1 per cent. iron ore in stoppered bottle with small air space. (b.) Same as (a), but no iron ore. (Control experiment.)	Days. 6	(a.) Acid (b.) Neutral	0.24 0.06
2	June 6th, 1895:— Same as (a) (b), Experiment 1 . . . .	15	(a.) Acid (b.) Neutral	0.38 0.06
3	June 6th, 1895:— (a.) Boiled distilled water + 1 per cent. iron ore in stoppered bottle with large air space. (b.) Same as (a), but no iron ore. (Control experiment.)	6	(a.) Faintly acid. (b.) Neutral	0.18 0.06
4	June 6th, 1895:— Same as (a) (b), Experiment 3 . . . .	15	(a.) Faintly acid. (b.) Neutral	0.18 0.06
5	June 9th, 1895:— Acid peat water, obtained in the following way:— 1,000 c.c. boiled distilled water filtered through 100 grms. Bentham peat in double muslin filter. (a.) 100 c.c. of this acid water + 0.1 per cent. iron ore in stoppered bottle with large air space. (b.) same as (a), but no iron ore. (Control experiment.)	19	(a.) Acid (b.) Acid	0.24 0.29
6	June 10th, 1895:— Same as (a) (b), Experiment 3 . . . .	16	(a.) Faintly acid. (b.) Neutral	0.20 0.06
7	June 10th, 1895:— Same as (a) (b), Experiment 3 . . . .	16	(a.) Acid (b.) Neutral	0.24 0.06
8	June 10th, 1895:— Same as (a) (b), Experiment 1 . . . .	16	(a.) Acid (b.) Neutral	0.24 0.06

TABLE CXXVIII.—*continued*.

Experiment	Description of Experiment.	Water siphoned off after	Acidity—	
			Reaction with Lacmoid.	In Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.
9	June 10th, 1895:— Same as (a) (b), Experiment 1 - - -	Days. 16	(a.) Acid (b.) Neutral	0·30 0·06
10	June 12th, 1895:— (a.) Mossley water (which is acid in reaction) + 0·1 per cent. iron ore in stoppered bottles with large air space. (b.) same as (a), but no iron ore. (Control experiment.)	17	(a.) Faintly acid. (b.) ? Acid	0·24 0·18
11	June 12th, 1895:— Same as (a) (b), experiment 10, but Shipley water (which has acid reaction).	17	(a.) Acid (b.) Acid	0·78 0·72
12	June 25th, 1895:— Same as (a) (b), Experiment 10 - - -	30	(a.) ? Acid (b.) ? Acid	0·20 0·12
13	June 25th, 1895:— Same as (a) (b), Experiment 11 - - -	30	(a.) Acid (b.) Acid	0·60 0·66
14	July 3rd, 1895:— Same as (a) (b), Experiment 13 - - -	51	(a.) Acid (b.) Acid	0·72 0·66
15	July 3rd, 1895:— Same as (a) (b), Experiment 10 - - -	51	(a.) ? Acid (b.) Neutral	0·18 0·12
16	July 11th, 1895:— (a.) 100 c.c. Shipley water (which has acid re- action) + 0·1 per cent. iron ore in stoppered bottle with small air space. (b.) Same as (b), but no iron ore.	200	(a.) Acid (b.) Acid	0·66 0·60
17	July 11th, 1895:— Same as (a) (b), Experiment 16, but Mossley water.	200	(a.) Acid (b.) ? Trace acid.	0·12 0·12

The so-called "iron ore," which was scraped from the surface of the marl underlying the peat on the Shipley moorland gathering ground, conferred on neutral distilled water a slightly acid reaction, but did not increase the acidity of acid moorland waters to any very appreciable extent, moreover, there was no indication of such "iron ore" having any power of progressively increasing the acidity of moorland waters, even when the mixture of "iron ore" and water was kept for long periods. The results as a whole seem to indicate that the samples of "iron ore" (so-called) used in the experiments had no material influence as regards acid production; and that the presence of this substance in the marl underlying the peat could have no real influence on the production of acidity in moorland waters.

Table CXXIX., dealing with the effect, as regards acidity and plumbo-solvency, of adding peat (with and without iron ore and peat iron ore) to distilled water, and keeping for varying periods in stoppered bottles with air space, confirms the above results.

TABLE CXXIX.

Showing the EFFECT, as regards ACIDITY and ACTION on LEAD, of adding PEAT (with and without Iron Ore and Peat Iron Ore) to DISTILLED WATER, and keeping the Mixture for varying Periods in Stopped Bottles with Air Space.

[The peat was tied up in a muslin bag, and the distilled water was previously boiled. The action on lead was tested by upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 mins. per 50 c.c.]

Experiment.	Description of the Experiment.	Tested after	Acidity.			Action on Lead (Results stated as Parts per 100,000).					
			Reaction with Lacmoid.	In Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
1	June 8th, 1895 :— (a.) 10 grms. Bentham peat + 1 grm. iron ore in 500 c.c. distilled water - (b.) 10 grms. Bentham peat + 0 in 500 c.c. distilled water - (c.) 500 c.c. of the same distilled water -	Days. { 9 { (a.) Acid (b.) " (c.) Neutral	0.96 1.08 *0.12	0.1 0.1 0.0	0.2 0.2 0.0	0.2 0.3 0.0	0.3 0.4 0.0	0.4 0.4 0.0	0.24 0.28 0.00		
2	June 8th, 1895 :— (a.) 10 grms. Bentham peat + 1 grm. iron ore in 500 c.c. distilled water - (b.) Same as (a) - (c.) Same as (a), but no iron ore - (d.) Same as (c) - (e.) 1 grm. iron ore in 500 c.c. distilled water - (f.) 500 c.c. of the same distilled water -	Days. { 9 { (a.) Acid (b.) " (c.) " (d.) " (e.) Neutral (f.) "	0.72 0.72 1.08 0.84 *0.12 *0.12	0.1 0.1 0.1 0.1 0.0 0.0	0.1 0.2 0.2 0.2 0.0 0.0	0.2 0.2 0.3 0.3 0.0 0.0	0.2 0.2 0.4 0.3 0.0 0.0	0.3 0.3 0.6 0.4 0.0 0.0	0.18 0.20 0.32 0.24 0.00 0.00		

\* 100 c.c. of a neutral water requires about 0.12  $\frac{1}{10}$   $\text{Na}_2\text{CO}_3$  to give a decided pink colour with phenol-phthalein.

TABLE OXXIX.—*continued.*

Experiment.	Description of the Experiment.	Tested after	Acidity.		Action on Lead (Results stated as Parts per 100,000).						
			Reaction with Lacmoid.	In Terms of c.c. 10 N <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
3	June 12th, 1895 — (a.) 10 grms. Settle peat + 1 grm. iron ore in 500 c.c. distilled water (b.) 10 grms. Settle peat + 1 grm. peat iron ore in 500 c.c. distilled water (c.) 10 grms. Settle peat + 0 in 500 c.c. distilled water (d.) 500 c.c. of the same distilled water	Days. 6	(a.) Acid	0·84	0·3	0·6	0·6	0·6	0·6	0·6	0·54
			(b.) "	0·60	0·1	0·4	0·5	0·5	0·5	0·5	0·40
			(c.) "	0·72	0·2	0·4	0·5	0·6	0·6	0·6	0·46
			(d.) Neutral	0·12	0·0	0·0	0·0	0·0	0·0	0·0	0·00
4	June 19th, 1895 — (a.) 10 grms. Bradford peat + 0·1 grm. iron ore in 500 c.c. distilled water (b.) 10 grms. Bradford peat + 0·1 grm. peat iron ore in 500 c.c. distilled water (c.) 10 grms. Bradford peat + 0 in 500 c.c. distilled water (d.) 500 c.c. of the same distilled water	10	(a.) Acid	0·00	0·4	0·7	0·8	0·8	0·8	0·9	0·72
			(b.) "	0·00	0·4	0·7	0·8	0·8	0·8	0·9	0·72
			(c.) "	0·84	0·5	0·9	0·9	1·0	1·0	0·86	
			(d.) Neutral	0·12	0·0	0·0	0·0	0·0	0·0	0·0	0·00
5	June 29th, 1895 — (a.) 10 grms. Bradford peat + 10 grms. iron ore in 500 c.c. distilled water (b.) 10 grms. Bradford peat + 0 (c.) 10 grms. iron ore in 500 c.c. distilled water (d.) 500 c.c. of the same distilled water	6	(a.) Acid	1·44	1·0	1·0	1·2	1·2	1·2	1·2	1·12
			(b.) "	0·96	0·8	1·4	1·6	1·6	1·6	1·8	1·44
			(c.) faint.	0·24	0·1	0·2	0·2	0·2	0·2	0·3	0·20
			(d.) Neutral	0·12	0·0	0·0	0·0	0·0	0·0	0·0	0·00

The iron ore was taken from the surface of the marl forming the bed of the feeders which drain the acid water from the peat on Shipley moorland gathering ground. The peat iron ore was taken from the surface peat on Shipley moorland gathering ground. In the cases where iron ore and peat iron ore were used, the water was less cloudy, and there appeared to be less bacterial growth.

It will be seen that the addition of the iron ore and peat iron ore to the peat did not confer on the peat an *additional* power of rendering neutral water acid and did not *increase* the solvent action of the water on lead.

In the following table (Table CXXX.) the result, as regards acidity, of certain experiments in which distilled water and rain-water were mixed with marcasite, iron pyrites, sandstone, shale, and "bog iron ore" are shown :—

TABLE CXXX.

Showing the RESULT, as regards ACIDITY, of certain EXPERIMENTS in which Distilled Water and Rain-water were mixed with one of the following Substances :—Marcasite ( $\text{FeS}_2$ ) ; Iron Pyrites ( $\text{FeS}_2$ ) ; Sandstone ; Shale ; and "Bog Iron Ore."

No.	Description of the Experiment.	Acidity.		Remarks.
		Reaction with Lacmoid.	In Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	
1.	February 19th, 1896 :— (a.) 200 c.c. boiled distilled water (neutral) + 0·5 per cent. powdered marcasite ( $\text{FeS}_2$ ) in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), but the water was kept until March 25th, 1896, before being tested.	(a.) ? Trace acid. (b.) Acid	(a.) 0·24 (b.) 2·16	Unless otherwise stated, phenol - phthalein was used as indicator in estimating the amount of the acidity in all the experiments.
2.	February 19th, 1896 :— (a.) 200 c.c. rain-water + 0·5 per cent. powdered marcasite ( $\text{FeS}_2$ ) in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), Experiment 2. The water was kept until March 25th, 1896, before being tested.	(a.) Neutral (b.) Acid	(a.) 0·36 (b.) 1·42	Marcasite is said to be more easily oxidised than iron pyrites.
3.	February 19th, 1896 :— (a.) 200 c.c. boiled distilled water (neutral) + 0·5 per cent. powdered ferruginous sandstone in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), Experiment 3. The water was kept until March 23th, 1896, before being tested.	(a.) Neutral (b.) Neutral	(a.) 0·18 (b.) 0·18	The ferruginous sandstone was obtained from moorland near Slaidburn.
4.	February 19th, 1896 :— (a.) 200 c.c. rain-water + 0·5 per cent. powdered ferruginous sandstone in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), Experiment 4. The water was kept until March 25th, 1896, before being tested.	(a.) Neutral (b.) Neutral	(a.) 0·24 (b.) 0·24	

TABLE CXXX.—*continued.*

No.	Description of the Experiment.	Acidity.		Remarks.
		Reaction with Lacmoid.	In Terms of c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	
5	March 5th, 1896 :— (a.) 200 c.c. boiled distilled water (neutral) + 1 per cent. powdered iron pyrites ( $\text{FeS}_2$ ) in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), Experiment 5. The water was kept until April 14th, 1896, before being tested.	(a.) Neutral (b.) Acid	(a.) 0·18 (b.) 5·76	In 5 (b) the end reaction was obscure. Tested with methyl-orange as indicator instead of with phenol - phthalein, the result was 2·04 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ .
6	March 5th, 1896 :— (a.) 200 c.c. rain - water + 1 per cent. powdered iron pyrites ( $\text{FeS}_2$ ) in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), Experiment 6. The water was kept until April 14th, 1896, before being tested.	(a.) Neutral (b.) Acid	(a.) 0·24 (b.) 3·36	In 5 (b) the end reaction was obscure. Tested with methyl-orange the result was 0·36, as compared with 3·36 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ with phenol - phthalein as indicator.
7	March 5th, 1896 :— (a.) 200 c.c. boiled distilled water (neutral) + 1 per cent. powdered shale in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), Experiment 7. The water was kept until April 14th, 1896, before being tested.	(a.) ? Trace acid. (b.) Neutral	(a.) 0·18 (b.) 0·12	The sample of shale used in Experiments 7, 8, and 10 contained a large proportion of iron. The shale was obtained from moorland near Slaidburn.
8	March 6th, 1896 :— (a.) 200 c.c. rain - water + 1 per cent. powdered shale in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment. (b.) Same as (a), Experiment 8. The water was kept until April 14th, 1896, before being tested.	(a.) ? Trace acid. (b.) ? Trace acid.	(a.) 0·24 (b.) 0·20	
9	March 14th, 1896 :— (a.) 100 c.c. boiled distilled water, (neutral) + 1 per cent. powdered marcasite in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. (b.) Same as (a.), Experiment 9, but the water and marcasite heated in a steam steriliser to 100° C. for three hours. After one day water siphoned off and tested for acidity. (c.) 1 grm. marcasite heated in a steam steriliser to 100° C. for three hours, then 100 c.c. distilled water added. After one day water siphoned off and tested for acidity.	(a.) Acid (b.) Acid (c.) Acid	(a.) 0·72 (b.) 0·72 (c.) 0·48	
10	March 14th, 1896 :— (a.) Same as (a), Experiment 9, but powdered shale used instead of marcasite. (b.) Same as (b), Experiment 9, but powdered shale used instead of marcasite. (c.) Same as (c), Experiment 9, but powdered shale used instead of marcasite.	(a.) Trace acid. (b.) Trace acid. (c.) Trace acid.	(a.) 0·30 (b.) 0·36 (c.) 0·30	

TABLE CXXX.—*continued.*

No.	Description of the Experiment.	Acidity.		Remarks.
		Reaction with Lacmoid.	In Terms of c.c. $\frac{1}{10}$ $\text{N}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	
11	<p>April 9th, 1896:—</p> <p>(a.) 1 grm. powdered marcasite in stoppered bottle with large air space.</p> <p>(b.) Same as (a), Experiment 11, but the marcasite was first moistened with distilled water.</p> <p>On April 26th, 100 c.c. boiled distilled water added to (a) and (b). The following day the water was carefully siphoned off and tested for acidity.</p>	<p>(a.) ? Trace acid.</p> <p>(b.) Acid</p>	<p>(a.) 0·12</p> <p>(b.) 0·48</p>	
12	<p>May 3rd, 1896:—</p> <p>(a.) 100 c.c. boiled distilled water (neutral) + 1 per cent. powdered "bog iron ore" in stoppered bottle with large air space. After one day water siphoned off and tested for acidity. Control experiment.</p> <p>(b.) Same as (a), Experiment 12. The water was kept until May 20th, 1896, before being tested.</p> <p>(c.) Same as (a), Experiment 12. The water was kept until June 17th, 1896, before being tested.</p>	<p>(a.) Slightly acid.</p> <p>(b.) Slightly acid.</p> <p>(c.) Slightly acid.</p>	<p>(a.) 0·48</p> <p>(b.) 0·30</p> <p>(c.) 0·30</p>	<p>The so-called "bog iron ore" was a deposit of iron in and under the peat, and was obtained from the Oldham gathering ground. It appeared to consist chiefly of carbonate of iron, mixed with clay and vegetable matter.</p>
13	<p>May 3rd, 1896:—</p> <p>(a.) Same as (a), Experiment 12, but rain-water used instead of distilled water.</p> <p>(b.) Same as (b), Experiment 12, but rain-water used instead of distilled water.</p> <p>(c.) Same as (c), Experiment 12, but rain-water used instead of distilled water.</p>	<p>(a.) ? Trace acid.</p> <p>(b.) Neutral</p> <p>(c.) Neutral</p>	<p>(a.) 0·48</p> <p>(b.) 0·13</p> <p>(c.) 0·18</p>	<p>In 12 (a) and 13 (a) the clay had not entirely subsided when the water was siphoned off. Hence, the end action being obscure, the acidity appeared to be greater than was probably actually the case.</p>

The effect of the addition of marcasite and iron pyrites to the waters was, as might have been anticipated, to confer on them, after keeping for some time, strongly acid properties. As regards the sandstone, shale, and "bog iron ore," all of which substances are commonly to be found on moorland gathering grounds, the result was practically negative as far as production of acidity was concerned.

By way of summarising the above tables it may be said that peat ash, sulphide of iron ( $\text{FeS}$ ), "iron ore," sandstone, and shale appeared to have little or no influence in producing acid; but that marcasite ( $\text{FeS}_2$ ) and iron pyrites ( $\text{FeS}_2$ ) are capable, by oxidation processes, of rendering neutral waters strongly acid.

At this point, it will not be amiss to consider the results shown in Table CXXXI. The table deals with the results, as regards acidity and plumbo-solvency, of certain experiments with marcasite ( $\text{FeS}$ ), iron pyrites ( $\text{FeS}_2$ ), sandstone, and shale.



TABLE CXXXI.

Showing the RESULTS, as regards ACIDITY and PLUMBO-SOLVENCY, of certain EXPERIMENTS with Marcasite ( $\text{FeS}_2$ ), Iron Pyrites ( $\text{FeS}_2$ ), Sandstone, and Shale.

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10} \text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	100 grms. Settle peat in muslin bag hung outside laboratory so as to be exposed to atmospheric influences from February 20th to March 28th, 1896. Then 1,000 c.c. boiled distilled water (neutral and free from plumbo-solvent ability) filtered slowly through the peat, placed in a muslin filter, in a funnel.	Acid	0.54	0.1	0.2	0.3	0.3	0.4	0.26
2	Conditions same as in Experiment 1, except that 1 grm. powdered marcasite ( $\text{FeS}_2$ ) first added to the peat.	Acid	0.54	0.2	0.4	0.4	0.6	0.8	0.48
3	100 grms. Settle peat spread out in shallow glass dish, and covered with muslin, and exposed to atmospheric influences from February 20th to April 6th, 1896. The peat was then placed in a muslin filter in a funnel, and 1,000 c.c. boiled distilled water (neutral and free from plumbo-solvent ability) slowly filtered through the peat.	Acid	0.30	0.1	0.2	0.3	0.3	0.3	0.24
4	Conditions same as in Experiment 3, but 1 grm. powdered marcasite ( $\text{FeS}_2$ ) first mixed with the peat.	Acid	0.42	0.4	0.8	0.9	0.9	0.9	0.78
5	100 grms. Settle peat in muslin filter in funnel. 1,000 c.c. boiled distilled water (neutral and free from plumbo-solvent ability) filtered slowly through the peat. February 21st, 1896.	Acid	0.36	0.2	0.4	0.6	0.6	0.6	0.48
6	Conditions same as in Experiment 5, but 1 grm. powdered marcasite ( $\text{FeS}_2$ ) first mixed with the peat.	Acid	0.36	0.2	0.4	0.4	0.6	0.6	0.44

TABLE CXXXI.—*continued.*

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{m}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 cc.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
7	1,000 c.c. distilled water again filtered through the same peat as in Experiment 5. February 23rd, 1896.	Ft. acid	0.24.	0.1	0.1	0.2	0.2	0.2	0.16
8	1,000 c.c. distilled water again filtered through the same peat as in Experiment 6. February 23rd, 1896.	Ft. acid	0.24	0.1	0.2	0.2	0.2	0.2	0.18
9	February 28th, 1896. Experiment 7 repeated.	V. ft. acid	0.20	0.0	0.0	0.1	0.1	0.1	0.06
10	February 28th, 1896. Experiment 8 repeated.	V. ft. acid	0.20	0.1	0.1	0.1	0.1	0.1	0.10
11	March 5th, 1896. Experiment 7 repeated.	V. ft. acid	0.20	0.0	0.0	0.0	0.1	0.1	0.04
12	March 5th, 1896. Experiment 8 repeated.	V. ft. acid	0.20	0.0	0.1	0.1	0.1	0.1	0.06
13	March 14th, 1896. Experiment 7 repeated.	V. ft. acid	0.20	0.0	0.1	0.1	0.1	0.1	0.06
14	March 14th, 1896. Experiment 8 repeated.	V. ft. acid	0.20	0.1	0.2	0.2	0.2	0.2	0.22
15	March 25th, 1896. Experiment 7 repeated.	Acid	0.24	0.2	0.3	0.3	0.4	0.5	0.34
16	March 25th, 1896. Experiment 8 repeated.	Acid	0.30	0.3	0.5	0.5	0.5	0.5	0.46
17	April 10th, 1896. Experiment 7 repeated.	Ft. acid	0.20	0.1	0.1	0.2	0.2	0.4	0.20
18	April 10th, 1896. Experiment 8 repeated.	Acid	0.30	0.1	0.5	0.5	0.5	0.5	0.42
19	May 6th, 1896. Experiment 7 repeated.	Ft. acid	0.30	0.2	0.3	0.4	0.4	0.4	0.34
20	May 6th, 1896. Experiment 8 repeated.	Acid	0.48	0.6	1.0	1.2	1.2	1.4	1.06
21	10 grms. Settle peat tied in muslin bag and placed in stoppered bottle (with large air space) containing 500 c.c. distilled water (neutral and free from plumbo-solvent ability). February 24th, 1896. Tested March 3rd, 1896.	Acid	0.42	0.0	0.1	0.1	0.2	0.2	0.12
22	Conditions same as in Experiment 21, but 0.1 gm. powdered marcasite first mixed with the peat.	Acid	0.42	0.1	0.3	0.4	0.4	0.4	0.32

TABLE CXXXI.—*continued.*

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 cc.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
23	100 grms. Settle peat tied up in double muslin bag and hung outside laboratory so as to be exposed to atmospheric influences from March 6th to May 23rd, 1896. The peat was then placed in a muslin filter in a glass funnel and 1,000 c.c. boiled distilled water (neutral and free from plumbosolvent ability) slowly filtered through the peat. The filtrate was tested for acidity and plumbosolvent ability.	Acid	0.60	0.2	0.4	0.4	0.4	0.4	0.36
24	Conditions same as in Experiment 23, except that 1 gm. powdered iron pyrites ( $\text{FeS}_2$ ) first mixed with the peat.	Acid	0.96	0.6	1.2	1.6	1.6	1.6	1.32
25	Conditions same as in Experiment 23, except that 1 gm. powdered shale (the sample was obtained from Bacup moorland gathering ground) first mixed with the peat.	Acid	0.60	0.2	0.4	0.4	0.6	0.6	0.44
26	10 grms. Settle peat tied in muslin bag and placed in stoppered bottle with large air space containing 500 c.c. boiled distilled water (neutral and free from plumbosolvent ability). March 4th, tested March 26th, 1896.	Acid	0.48	0.3	0.4	0.5	0.5	0.6	0.46
27	Conditions same as in Experiment 26, except that 0.1 gm. powdered iron pyrites ( $\text{FeS}_2$ ) first added to the peat.	Acid	0.30	0.2	0.3	0.4	0.4	0.5	0.36
28	Conditions same as in Experiment 26, except that 0.1 gm. powdered shale (the sample was obtained from Bacup Moorland gathering ground) first mixed with the peat.	Acid	0.54	0.2	0.5	0.5	0.5	0.5	0.44
29	500 c.c. boiled distilled water (neutral and free from plumbosolvent ability) + 0.8 gm. powdered marcasite ( $\text{FeS}_2$ ) in stoppered bottle with large air space. March 26th, 1896. The following day the water was carefully siphoned off and tested for acidity and plumbosolvent ability.	Acid	0.42	Experiment failed.					

TABLE CXXXI.—continued.

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 cc.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
30	Conditions same as in Experiment 29, but the water was not tested until March 23th.	Acid	0.54	0.2	0.8	1.2	1.2	1.2	*0.82
31	Conditions same as in Experiment 29, but the water was not tested until April 3rd.	Acid	0.96	1.2 1.2	2.0 1.2	2.0 1.8	2.0 1.8	2.8 2.0	*2.00 †1.60
32	Conditions same as in Experiment 29, but the water was not tested until April 11th, 1896.	Acid	1.56	1.5 1.0	2.5 2.0	2.5 2.0	2.5 2.0	2.5 2.0	*2.30 †1.80
33	Conditions same as in Experiment 29, but the water was not tested until April 24th, 1896.	Acid	2.64	3.0 2.0	3.0 3.0	4.0 3.0	4.0 3.0	4.0 3.0	*3.60 †2.80
34	500 c.c. boiled distilled water (neutral and free from plumbosolvent ability) + 0.5 grms. powdered iron pyrites ( $\text{FeS}_2$ ), in stoppered bottle with large air space. March 31st, 1896. The following day (April 1st, 1896) the water was carefully siphoned off and tested for acidity and plumbosolvency.	Acid	0.42	Experiment failed.					
35	Conditions same as in Experiment 34, but the water was not tested until April 8th, 1896.	Acid	1.14	0.2	1.0	1.0	1.0	1.2	*0.82
36	Conditions same as in Experiment 34, but the water was not tested until April 16th, 1896.	Acid	1.90	1.2	2.4	2.8	2.8	2.8	*2.40
37	Conditions same as in Experiment 34, but the water was not tested until April 26th, 1896.	Acid	2.64	2.0	3.0	3.0	3.0	3.0	*2.80
38	Conditions same as in Experiment 34, but the water was not tested until May 5th, 1896.	Acid	3.84	4.0 2.0	4.0 3.0	4.0 3.0	4.0 3.0	4.0 3.0	*4.00 †2.80
39	500 c.c. Venomous Clough No. 1 water (Bacup) + 1 per cent. powdered sandstone rock in stoppered bottle with large air space. The sandstone rock was taken from under the peat on Bacup moorland gathering ground. Experiment started April 1st, and on April 24th, 1896, the water was carefully siphoned off and tested for acidity and plumbosolvent ability.	Acid [Acid	0.80 0.78	0.6 0.6	0.8 1.2	1.0 1.6	1.0 1.6	1.0 1.6	0.82 1.32]

The figures in brackets represent the acidity and plumbosolvent ability of the same water when not "treated" in any way.

\*  $\text{K}_2\text{CrO}_7$  used in estimating the amount of the action on lead.

†  $(\text{NH}_4)_2\text{S}$  used (as in all the other experiments) in estimating the amount of the action on lead.

TABLE CXXXI.—*continued.*

Experiment.	Description of the Experiment.	Reaction with Leucoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 min. per 50 c.c.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
40	Conditions same as in Experiment 39, except that the water was the "inlet" water to Sheephouse Clough Reservoir.	Acid	0.42	0.2	0.4	0.6	0.8	0.8	0.53
		[Acid]	0.43	0.2	0.4	0.6	0.8	0.8	0.56
		The figures in brackets represent the acidity and plumbo-solvent ability of the same water when not "treated" in any way.							
41	Conditions same as in Experiment 39, except that 1 per cent. powdered shale (which underlies the sandstone rock on Bacup moorland gathering ground) used, and the water from Venomous Clough, No. 2.	Acid	0.98	1.5	1.5	1.5	1.5	2.0	1.60
		[Acid]	1.08	1.5	2.0	2.5	2.5	2.5	2.20
		The figures in brackets represent the acidity and plumbo-solvent ability of the same water when not "treated" in any way.							
42	Conditions same as in Experiment 39, except that 1 per cent. powdered shale (which underlies the sandstone rock on Bacup moorland gathering ground) used, and the water from Sheephouse Clough Reservoir.	Acid	0.68	0.4	0.6	0.8	1.0	1.0	0.76
		[Acid]	0.68	0.8	1.2	1.2	1.6	1.6	1.28
		The figures in brackets represent the acidity and plumbo-solvent ability of the same water when not "treated" in any way.							

Experiments 1, 2, 3, 4 deal with the effect, as regards acidity and plumbo-solvency, of "weathering" peat alone and also peat mixed with iron pyrites and with marcasite. The filtrate from the peat mixed with iron pyrites and with marcasite acted more strongly on lead than did the filtrate from the peat alone. Experiments 5 to 20 deal with the effect, as regards acidity and plumbo-solvency, of filtering at intervals neutral distilled water through peat alone and through peat mixed with powdered marcasite. Under the latter set of conditions, the filtrate was usually more acid and acted more strongly on lead than under the former; but the difference was not so well marked as might have been theoretically anticipated. Incidentally, these peat filtration experiments illustrate an aspect of the subject which will presently receive adequate consideration, viz., the ability of peat to confer acid and plumbo-solvent qualities on a neutral water slowly filtered through it. Experiments 21 and 22 deal with the effect, as regards acidity and plumbo-solvency, of leaving peat alone and peat mixed with marcasite for some time in contact with a large bulk of neutral water. The acidity, in both cases, was found to be the same; but the action on lead was more vigorous in Experiment 22, where the marcasite was mixed with the peat, than in Experiment 21, when peat alone was used. Incidentally, these experiments illustrate a side of the subject which will presently be fully considered, viz., the effect, as regards acidity and plumbo-solvency, of leaving peat for a long time in contact with neutral water. Experiments 23, 24, and 25 deal with the effect, as regards acidity and plumbo-solvency, of "weathering" peat alone (Experiment 23) and peat mixed

with iron pyrites (Experiment 24), and also peat mixed with shale (Experiment 25). Experiments 23 and 25 yielded very similar results, as regards the acidity and plumbo-solvency of their respective filtrates, although the action on lead was somewhat greater in Experiment 25 than in Experiment 23. The difference, however, was so slight as to be covered by the error of experiment. As regards Experiment 24, both the acidity and plumbo-solvent ability of the filtrate were distinctly greater than that of the filtrates belonging to Experiments 23 and 25. The conditions in Experiments 26, 27, and 28 were similar to those in Experiments 21 and 22, except that instead of marcasite, iron pyrites (Experiment 27) was used, and powdered shale (Experiment 28) was also employed. Allowing for the errors of experiment (necessarily great in experiments of the above kind), the differences, as regards acidity and plumbo-solvency, were not wide in the three separate cases. But, as it happened, the results were actually lower in Experiment 27 (iron pyrites) than in Experiment 26 (control), or in Experiment 28 (powdered shale).

In Experiments 29, 30, 31, 32, 33 the effect, as regards acidity and plumbo-solvency, of the addition of marcasite to neutral distilled water is shown. It will be seen that the treatment the water was experimentally subjected to rendered it acid and plumbo-solvent in character, and that the longer the duration of contact, the greater also became the acidity and plumbo-solvent ability. Similar results were obtained with iron pyrites, as is shown in Experiments 34, 35, 36, 37, and 38. Experiments 39 and 40 deal with the effect, as regards acidity and plumbo-solvency, of adding powdered sandstone rock to acid moorland waters and keeping the mixture for some time in stoppered bottles. Similar experiments were carried out with powdered shale (Experiments 41 and 42). It is to be noted that both the sandstone and shale appeared, if anything, to reduce slightly the initial acidity and plumbo-solvent ability of the moorland waters.

The table contains so many details that it is difficult to summarise briefly its contents. The main facts, however, would seem to be as follows:—Both marcasite and iron pyrites, when mixed and left in contact for some time with either peat or neutral distilled water, tend to render the filtrate from the peat more acid and plumbo-solvent than the filtrate from “untreated” peat, and to confer on the distilled water acid and plumbo-solvent properties previously absent. Sandstone and shale, on the other hand, either have little or no influence, or they may even tend to correct the initial acidity and plumbo-solvent ability of moorland waters previously endowed with these attributes.

So much has been said of the effect, as regards acidity and plumbo-solvency, of the addition of iron pyrites to water, that it seems opportune at this stage of the report to consider the results shown in Tables CXXXII. and CXXXIII.

Table CXXXII. shows the results, as regards acidity and action on lead, of the examination of an acid water issuing from coal-workings (rich in iron pyrites), on Rochdale moorland gathering ground. At one time this water was allowed to enter the waterworks; but this is no longer the case.

TABLE CXXXII.

Showing the RESULTS of the CHEMICAL EXAMINATION of an ACID WATER issuing from COAL WORKINGS (rich in Iron Pyrites) on ROCHDALE MOORLAND GATHERING GROUNDS.

Experiment.	Description of the Sample of Water.	Reaction with Lœmold.	Addity in Terms of c.c. as $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Plumbo-solvent Ability. (Results stated as Parts per 100,000.) The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 minutes per 50 c.c.					Iron (Fe. Parts per 100,000).	"Erosion" Experiments. 10 c.c. of the Water in Test Tube with bright Sheet Lead 1 x 1". After some time Lead removed, Acid added to Contents of Tube, and Amount of Lead estimated. Results stated as Pb. Parts per 100,000.	Remarks.
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.			
1	Sample of water issuing from coal workings on Rochdale moorland gathering ground. The coal is peculiarly rich in iron pyrites ( $\text{FeS}_2$ ). At one time this water was allowed to enter the waterworks but this is no longer the case. March 9th, 1896.	Acid	8.96 (phenolphthalein as indicator). 1.68 (methyl orange as indicator).	2.0	2.0	2.0	2.0	2.0	2.4	March 9th, 3 experiments, a and b. Tested March 19th, 1896. No action apparent, the lead being well coated. a = 1.5 } approximate. b = 1.5 }	There was a copious ppt. of sulphate on addition of $\text{BaCl}_2$ to a portion of the sample of water. The sample showed a large yellowish (iron) deposit. (a) 100 c.c. of the sample of water evaporated to dryness in platinum crucible, and then redissolved in 100 c.c. neutral distilled water. (b) 100 c.c. of the sample of water boiled for a few minutes in a platinum crucible. (a) and (b) tested for acidity with phenolphthalein as indicator. Results.—(a) = 7.2; (b) = 7.2 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . The equation explaining the acidity of the water may be considered to be as follows:— $\text{FeS}_2 + 70 + \text{H}_2\text{O} = \text{FeSO}_4 + \text{H}_2\text{SO}_4$ . Same remarks as in Experiment 1. Here the evaporation and boiling appeared to increase the acidity—the result being (a) = 10.8; (b) = 10.08 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .
2	March 21st, 1896. Another sample of water from the above source.	Acid	7.68 p.p. as indicator. 1.44 m.o. as indicator.	2.5	1.5	1.5	2.0	2.0	2.4	March 21st, 3 experiments, a and b. Tested April 6th, 1896. No action visible, the lead being well coated. a = 1.5 } approximate. b = 1.5 }	
3	April 8th, 1896. Another sample of water from the above source.	Acid	9.12 p.p. as indicator. 1.93 m.o. as indicator.	1.8	1.8	1.8	2.0	2.0	4.8	—	—





# Plate III

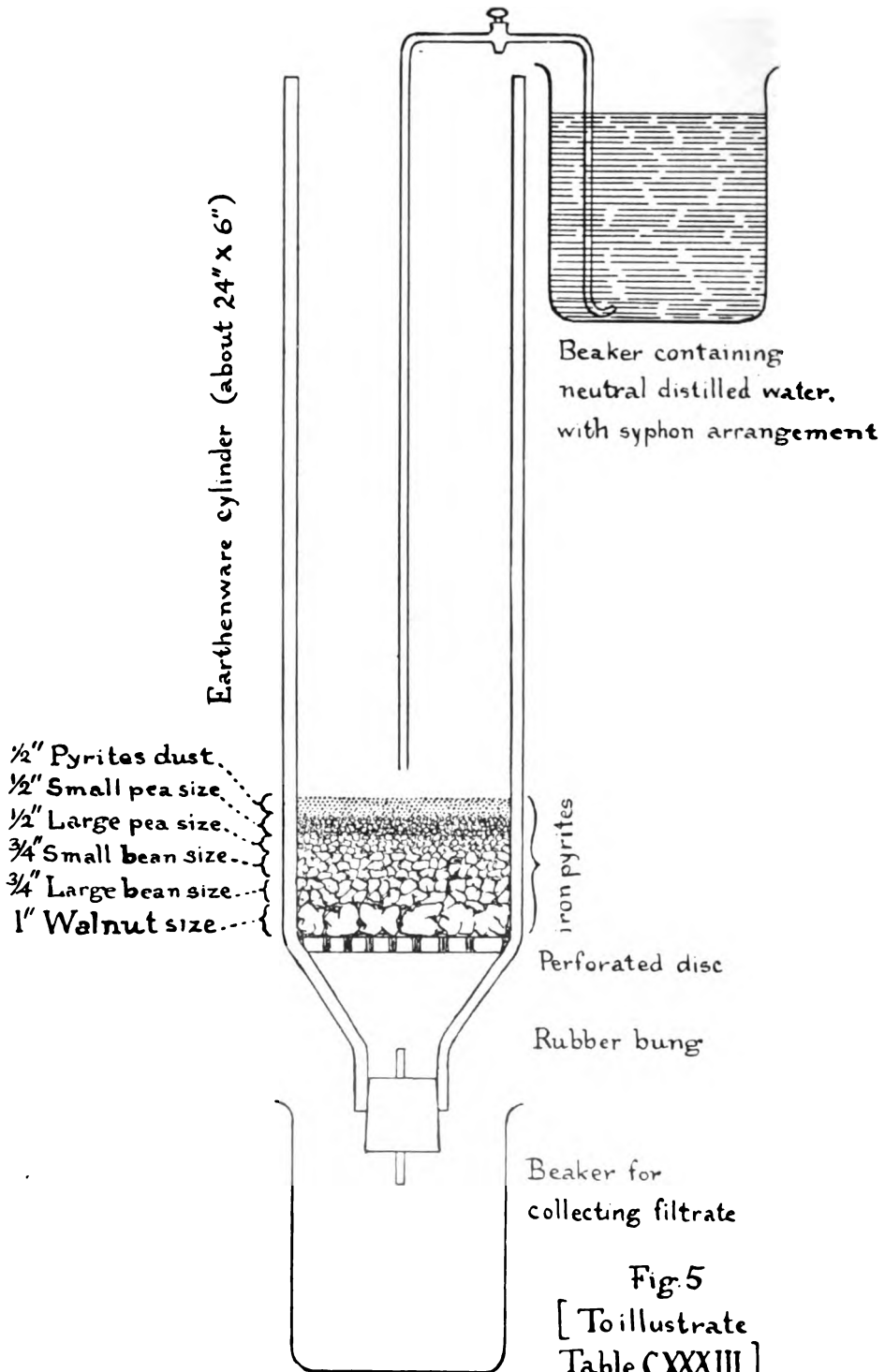


Fig. 5  
[ To illustrate  
Table CXXXIII ]

It will be seen from Table CXXXII. that the water was highly acid, relatively speaking, and dissolved lead to a considerable extent; but still seemingly not to the extent that might have been anticipated from the degree of acidity; that is to say, that many moorland waters giving, as regards acidity, considerably lower figures, possess a greater power of dissolving lead. As regards erosive power, the "bright" sheet lead became firmly coated and practically no erosion took place.

The table is important, because the oxidation of iron pyrites is believed by some authorities to be the antecedent cause of the acidity of moorland waters. That it may in certain instances be a factor contributing to this result is clearly indicated by the results of the above experiments.

With the view of testing the power of this pyrites rock to render acid water slowly filtering through it, a prolonged series of filtration experiments was carried out. The results and conditions of experiment are fully explained in Table CXXXIII., pages 254-63. See Fig. 5, Plate III.

It is to be noted that the water was rendered strongly acid and, when *sufficiently diluted* with a non-plumbo-solvent water, dissolved lead to a marked extent. No less than 101 experiments, extending over a prolonged period, namely, from April 9, 1896, to July 19, 1896, were carried out with distilled water. During this period neutral non-plumbo-solvent distilled water was slowly, but continuously, filtered through the pyrites filter, the total bulk of the filtrate amounting to 49,275 c.c.

From July 19 to August 11 (Experiments 102 to 112) Settle water (a hard limestone water possessed of considerable acid neutralising ability) was used instead of distilled water, the total bulk of water filtered through the pyrites filter during this period amounting to 12,000 c.c.

It is apparent from the above experiments that water slowly, but continuously, filtering through pyrites rock may become endowed to a dangerous extent with acid and plumbo-solvent properties, and that the copious dilution of the filtrate with a non-plumbo-solvent water in no way removes (within certain limits it even enhances) the solvent action of the water on lead. Erosion experiments, carried out with the undiluted filtrate, gave practically negative results, a firmly adherent film forming on the bright surface of the metal.

It is of advantage, in the next place, to consider an exhaustive series of experiments dealing with the potential qualities of peat, with regard to its power of rendering acid and plumbo-solvent certain neutral waters brought into contact with it.

The table on pages 264-286 (Table CXXXIV.) shows the effect, as regards acidity and plumbo-solvency, of leaving peat in contact with a large quantity of stagnant water.

TABLE CXXXIII.

Showing the EFFECT, as regards ACIDITY and PLUMBO-SOLVENCY, of filtering NON-PLUMBO-SOLVENT WATER through ROCK rich in IRON PYRITES ( $\text{FeS}_2$ ). The Samples of Rock were obtained from a Coal-working on the Moorland Gathering Ground of Rochdale Corporation Waterworks.

[The apparatus used in this experiment consisted of a glazed earthenware cylinder ( $24'' \times 6''$ ) tapered at its lower end to admit of the introduction of a rubber bung. A perforated earthenware disc rested near the lower end of the cylinder. The rock was broken up into fragments of various sizes and placed on the earthenware disc in layers as follows:—Beginning from below upwards.  $1''$  layer, walnut size.  $\frac{3}{4}''$  layer, large bean size.  $\frac{3}{4}''$  layer, small bean size.  $\frac{1}{4}''$  layer, large pea size.  $\frac{1}{4}''$  layer, small pea size.  $\frac{1}{4}''$  layer of pyrites dust. Water was allowed to drop in from above, slowly and continuously. The water after passing through the iron pyrites was carried by means of a glass tube fitted into the bung into a suitable vessel and examined periodically for acidity and plumbo-solvency. See Fig. 5, Plate III.]

Experiment.	Description of the Experiment.	Amount of Water filtered through the Pyrites.	Reaction with Leamoid.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. (Methyl-orange used as Indicator.)	Action on Lead (Results stated as Parts per 100,000.) The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 5 mins. per 50 c.c.					Remarks.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
		c.c.								
1	Experiment started April 9th, 1896. Distilled water, which had been previously boiled and which was neutral and free from plumbo-solvent ability, filtered slowly through the Pyrites.	900	Distinctly acid.	9.0	—	—	—	—	—	Notwithstanding its great acidity the water appeared to have no action on lead. The action on lead was tested on April 10, 11, 12, 13, 14, 15, 16, 17, 18, and 20, with negative results.
2	9 " " 11th "	500	"	6.0	—	—	—	—	—	
3	9 " " 12th "	500	"	6.0	—	—	—	—	—	



TABLE CXXXIII.—continued.

Experiment.	Description of the Experiment.	Amount of Water filtered through the Pyrites.	Reaction with Laccmoid.	Acidity in Terms of c.c. 10 Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Liquid (Methyl-orange used as Indicator).	Action on Lead (Results stated as Parts per 100,000).					Remarks.
					The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					
					1st. 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
23	9 a.m., May 2nd, 1896	-	-	6.0 { <sup>+</sup> 1.0	1.0	1.0	1.0	1.0	1.0	Diluted as in Experiment 28, and the tested for action on lead.
24	9 " " 3rd	-	-	6.0 { <sup>+</sup> 3.0	2.0	2.0	3.0	2.0	2.0	
25	9 " " 4th	-	-	7.8 { <sup>+</sup> 1.0	1.0	2.0	2.0	2.0	1.6	
26	9 " " 5th	-	-	6.0 { <sup>+</sup> 1.0	2.0	2.0	2.0	2.0	1.8	
27	9 " " 6th	-	-	7.8 { <sup>+</sup> 2.0	2.0	2.0	2.0	2.0	1.8	
28	9 " " 7th	-	-	9.0 { <sup>+</sup> 3.0	2.5	2.5	2.5	2.5	2.4	
29	9 " " 8th	-	-	9.0 { <sup>+</sup> 3.0	3.0	3.0	3.0	3.0	3.0	
30	9 " " 9th	-	-	8.0 { <sup>+</sup> 2.5	2.5	2.5	2.5	2.5	2.5	
31	9 " " 10th	-	-	10.8 { <sup>+</sup> 3.0	3.0	3.0	3.0	3.0	3.0	
32	9 " " 11th	-	-	10.8 { <sup>+</sup> 3.0	3.0	3.0	3.0	3.0	3.0	

Diluted as in Experiment 23, and the tested for action on lead.



TABLE CXXXIII.—*continued.*

Experiment.	Description of the Experiment.	Amount of Water filtered through the Pyrites.	Reaction with Leamoid.	Acidity in Terms of c.c. 10 $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid (Methyl-orange used as Indicator).	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 53 c.c.					Remarks.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
					Average.					
46	9 a.m., May 27th, 1898	300	Distinctly Acid.	36.0 { <sup>+</sup> 1.2 + 0.8	2.4 2.4	2.4 2.4	2.4 2.4	2.4 2.4	2.8 2.4	2.24 2.04
49	9 " " 28th "	300	"	36.0 { <sup>+</sup> 1.2 + 1.2	2.4 2.4	2.4 2.4	2.8 2.8	2.8 2.8	2.8 2.8	2.23 2.40
50	9 " " 29th "	450	"	30.6 { <sup>+</sup> 1.6 + 0.4	1.6 1.2	1.6 1.2	1.6 1.2	1.6 1.2	1.6 1.2	1.60 0.96
51	9 " " 30th "	300	"	38.0 { <sup>+</sup> 1.5 + 0.5	3.0 2.0	3.0 2.0	3.0 2.5	3.0 2.5	3.0 2.5	2.70 2.00
52	9 " " 31st "	300	"	38.0 { <sup>+</sup> 1.0 + 0.5	2.0 1.0	2.0 1.0	2.0 2.0	2.0 2.0	2.0 2.0	1.80 1.80
53	9 " June 1st "	550	"	18.0 { <sup>+</sup> 1.0 + 1.0	1.5 1.0	1.5 1.0	1.5 1.0	1.5 1.0	1.5 1.0	1.40 1.00
54	9 " " 2nd "	350	"	24.0 { <sup>+</sup> 1.0 + 0.5	1.5 1.0	1.5 1.0	2.0 1.5	2.0 1.5	2.0 1.5	1.70 1.20
55	9 " " 3rd "	300	"	42.0 { <sup>+</sup> 1.0 + 1.0	3.0 1.0	3.0 1.0	3.0 2.0	3.0 2.0	3.0 2.0	2.60 2.0
56	9 " " 4th "	400	"	30.0 { <sup>+</sup> 1.5 + 0.5	2.0 1.0	2.0 1.0	2.0 1.5	2.5 2.0	2.5 2.0	2.10 1.40
57	9 " " 5th "	500	"	30.0 { <sup>+</sup> 2.0 + 1.0	3.0 2.0	3.0 2.0	3.0 2.0	3.0 2.0	3.0 2.0	2.80 1.80

Diluted as in Experiment 41, and then tested for plumbo-solvency.

Diluted as in Experiment 41, and then tested for plumbo-solvency.





TABLE CXXXIII.—continued.

Experiment.	Description of the Experiment.	Amount of Water altered through the Pyrites.	Reaction with Leamoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid (Methyl-orange used as Indicator).	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
73	9 a.m., June 21st, 1896	650	Distinctly acid.	38.0 { + 1.0	2.5 2.0	2.5 2.0	3.0 2.0	3.3 2.5	3.5 2.5	2.90 2.00
74	9 " " 22nd "	550	"	30.0 { + 0.5	1.5 1.5	2.0 1.5	2.5 1.5	2.5 1.5	2.5 1.5	2.20 1.30
75	9 " " 23rd "	450	"	38.0 { + 1.0	2.0 2.5	3.0 2.5	3.0 2.5	3.0 2.5	3.0 2.5	2.80 2.20
76	9 " " 24th "	450	"	60.0 { + 3.0	4.0 3.5	5.0 3.5	4.5 3.5	4.5 3.5	5.0 3.5	4.60 3.30
77	9 " " 25th "	500	"	54.0 { + 1.0	3.5 3.0	4.0 3.0	4.0 3.0	4.0 3.0	4.0 3.0	3.90 2.60
78	9 " " 26th "	650	"	30.0 { + 1.0	1.5 1.5	2.5 1.5	2.5 1.5	2.5 1.5	2.5 1.5	2.30 1.40
79	9 " " 27th "	600	"	45.0 { + 1.0	3.0 2.5	3.0 2.5	3.5 2.5	3.5 2.5	3.5 2.5	3.10 2.20
80	9 " " 28th "	700	"	38.0 { + 1.0	2.0 2.0	3.0 2.0	3.0 2.0	3.0 2.0	3.0 2.0	2.80 1.90
81	9 " " 29th "	600	"	38.0 { + 1.0	2.0 2.0	3.0 2.0	3.0 2.0	3.0 2.0	3.0 2.0	2.80 1.80
82	9 " " 30th "	500	"	38.0 { + 1.0	2.0 2.0	3.0 2.0	3.5 2.0	3.5 2.0	4.0 2.0	3.20 1.80

Diluted as in Experiment 41, and then tested for plumbic-solvency.

83	4 p.m.	"	30th	"	"	500	"	38.0°	2.0	4.0	4.0	4.0	4.0	3.60
84	9 a.m.	"	July 1st	"	"	500	"	36.0°	2.0	3.5	3.5	3.5	3.5	3.20
85	9 "	"	"	2nd	"	500	"	30.0°	5.0	5.0	5.0	5.0	5.0	5.00
Very difficult to estimate correctly.														
86	9 "	"	"	3rd	"	750	"	15.0°	0.5	0.5	1.0	1.0	1.0	0.70
87	9 "	"	"	4th	"	900	"	13.0°	0.5	1.0	1.0	1.0	1.0	0.90
88	9 "	"	"	5th	"	650	"	30.0°	1.0	1.5	2.0	2.0	2.0	1.70
89	9 "	"	"	6th	"	700	"	48.0°	1.5	2.5	3.5	3.5	4.0	3.00
90	9 "	"	"	7th	"	750	"	36.0°	1.5	2.0	2.5	2.5	2.5	2.80
91	9 "	"	"	8th	"	700	"	30.0°	2.0	2.0	2.0	2.5	2.5	2.20
92	9 "	"	"	9th	"	300	"	75.0°	3.0	3.0	3.0	3.0	3.0	3.00
Action very difficult to estimate.														
93	9 "	"	"	10th	"	350	"	75.0°	3.0	3.0	3.0	3.0	3.0	3.00
Action very difficult to estimate.														
94	9 "	"	"	11th	"	250	"	75.0°	3.0	3.0	3.0	3.0	3.0	3.00
Action very difficult to estimate.														
95	9 "	"	"	12th	"	300	"	105.0°	6.0	6.0	6.0	6.0	6.0	6.00
96	9 "	"	"	13th	"	300	"	120.0°	5.0	6.0	6.0	6.0	6.0	5.80
97	9 "	"	"	14th	"	450	"	150.0°	4.0	4.0	4.0	4.0	4.0	4.00
98	9 "	"	"	15th	"	650	"	39.0°	1.5	2.0	3.0	3.0	3.0	2.70
99	9 "	"	"	16th	"	800	"	24.0°	1.0	1.5	1.5	1.5	2.0	1.50
100	9 "	"	"	17th	"	800	"	36.0°	2.0	2.0	3.0	3.0	3.0	2.60
101	9 "	"	"	18th	"	400 in 3 days.	"	75.0°	4.0	4.0	4.0	4.0	4.0	4.00
Action difficult to estimate.														
After 19th July Settle water (a hard limestone water) filtered through the pyrites instead of distilled water.														

Diluted as in Experiment 41, and then tested for plumbo-solvency.

\* Ammonium sulphide used in estimating the amount of lead.

† Bichromate of potassium used in estimating the amount of lead.

TABLE CXXXIII.—continued.

Experiment.	Description of the Experiment.	Amount of Water filtered through the Pyrites.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid (Methyl-orange used as Indicator).	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead shot at the Rate of 3 mins. per 50 c.c.					Remarks.
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
102 {	9 a.m., July 20th, 1898	c.c. 1,500 in } 5 days.	Distinctly acid.	24.0° Acidity difficult to estimate.	1.0	2.0 Action difficult to estimate.	2.0	2.0	2.0	1.80
9 "	21st " "									
103 {	9 " " 23rd " "	c.c. 850 in } 3 days.	"	36.0° Acidity difficult to estimate.	3.0	4.0 Action difficult to estimate.	4.0	4.0	4.0	3.80
9 "	25rd " "									
104 {	9 " " 24th " "	c.c. 700 in } 3 days.	"	38.0° Acidity difficult to estimate.	3.0	3.0 Action difficult to estimate.	4.0	4.0	4.0	3.20
9 "	26th " "									
105 {	9 " " 26th " "	c.c. 700 in } 3 days.	"	54.0° Acidity difficult to estimate.	3.0	4.0 Action difficult to estimate.	4.0	4.0	5.0	4.00
9 "	27th " "									
106 {	9 " " 28th " "	c.c. 850 in } 3 days.	"	60.0° Acidity difficult to estimate.	3.0	4.0 Action difficult to estimate.	4.0	4.0	4.0	3.800
9 "	29th " "									

107 {	9	"	"	30th	"	"	"	"	30° Acidity difficult to estimate.	2°0	2°0	3°0	3°0	3°0	2°60
	9	"	"	31st	"	"	"	"			Action difficult to estimate.				
108 {	9	"	"	August 1st	"	"	"	"	24°0° Acidity difficult to estimate.	1°0	1°0	1°5	1°5	2°0	1°40
	9	"	"	2nd	"	"	"	"			Action difficult to estimate.				
109 {	9	"	"	3rd	"	"	"	"	36°0° Acidity difficult to estimate.	2°0	3°0	3°0	3°0	3°0	2°30
	9	"	"	4th	"	"	"	"			Action difficult to estimate.				
110 {	9	"	"	5th	"	"	"	"	36°0° Acidity difficult to estimate.	1°0	2°5	2°5	2°5	2°5	2°30
	9	"	"	6th	"	"	"	"			Action difficult to estimate.				
111 {	9	"	"	7th	"	"	"	"	36°0° Acidity difficult to estimate.	1°0	3°0	3°0	3°0	3°0	2°60
	9	"	"	8th	"	"	"	"			Action difficult to estimate.				
112 {	9	"	"	9th	"	"	"	"	75°0° Acidity difficult to estimate.	3°0	4°0	4°0	4°0	4°0	3°30
	9	"	"	10th	"	"	"	"			Action difficult to estimate.				
	9	"	"	11th	"	"	"	"							

Diluted as in Experiment 41, and then  
tested for plumbo-solvency.

\* Ammonium sulphide used in estimating the amount of lead.

The filtrate was usually transparent and of a pale yellow to dark brown colour. "Erosion" experiments with the filtrate gave negative results—a firmly adherent film forming on the bright surface of the metal.

TABLE CXXXIV.  
Showing the EFFECT, as regards ACIDITY and PLUMBO-SOLVENCY, of leaving PEAT in CONTACT with a large QUANTITY of STAGNANT WATER. See Fig. 6, Plate IV.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re- action with Lac- moid.	Acidity in Terms of c.c. of $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Aver- age.	
1	1895. May 9		Grms. 500 Settle peat.	c.c. —	c.c. 9,680	Iron was occasionally tested for and found to be present.	Acid	—	—	—	—	—	—	—	The peat was obtained from moorland near Settle.
	" 10		—	100	100	—	"	0.12	—	—	—	—	—	—	
	" 11		—	100	100	—	"	0.18	—	—	—	—	—	—	
	" 12		—	100	100	—	"	0.24	—	—	—	—	—	—	
	" 13		—	100	100	—	"	0.36	—	—	—	—	—	—	
	June 1		—	100	100	—	"	0.42	—	—	—	—	—	—	
	" 15		—	100	100	—	"	0.54	—	—	—	—	—	—	
	" 16		—	100	100	—	"	0.54	—	—	—	—	—	—	
	" 17		—	100	100	—	"	0.60	—	—	—	—	—	—	
		500 grms. Settle peat placed at foot of glazed earthenware cylinder (38" x 8"). Distilled water (pre- viously boiled and neutral in reaction) slowly added until cylin- der nearly full.													



TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re- action with Lac- moid.	Acidity in Terms of c.c. of $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neu- tralise the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Aver- age.
3— cont.	1895, May 19		Grms. 1,000 Settle peat.	c.c.	c.c.	—	Acid	0.54	—	—	—	—	—	—	
"	" 20		—	100	100	—	"	0.60	—	—	—	—	—	—	
"	" 21		—	100	100	—	"	0.60	—	—	—	—	—	—	
"	" 22		—	100	100	—	"	0.66	—	—	—	—	—	—	
"	" 23		—	100	100	—	"	0.78	—	—	—	—	—	—	
"	" 24		—	100	100	—	"	0.84	—	—	—	—	—	—	
"	" 25		—	100	100	—	"	0.84	—	—	—	—	—	—	
"	" 26		—	100	100	—	"	0.84	—	—	—	—	—	—	
"	" 27		—	100	100	—	"	0.90	—	—	—	—	—	—	
"	" 28		—	100	100	—	"	1.08	—	—	—	—	—	—	
"	" 29		—	100	100	—	"	1.14	—	—	—	—	—	—	
"	" 30		—	100	100	—	"	1.14	—	—	—	—	—	—	
"	" 31		—	100	100	—	"	1.08	—	—	—	—	—	—	
"	June 1		—	100	100	—	"	1.14	—	—	—	—	—	—	
"	" 2		—	100	100	—	"	1.14	—	—	—	—	—	—	





TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Reaction with Lead- mold.	Acidity in Terms of c.c. of $\text{Na}_2\text{CO}_3$ required to neu- tralise the Water.	Action on Lead (Parts per 100,000). The action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Aver- age.
3— 1895.	cont. June 26		Grms. 1,000 Settle peat.	c.c. 100	c.c. 100	—	Acid	1.08	—	—	—	—	—	—	
" 27	"		—	100	100	—	"	1.08	—	—	—	—	—	—	
" 28	"		—	100	100	—	"	1.08	—	—	—	—	—	—	
" 29	"		—	100	100	—	"	1.08	—	—	—	—	—	—	
" 30	"		—	100	100	—	"	1.08	—	—	—	—	—	—	
July 1			—	100	100	—	"	0.98	—	—	—	—	—	—	
" 2	"		—	100	100	—	"	0.98	—	—	—	—	—	—	
" 3	"	Conditions same as in Experiment 1.	—	100	100	—	"	1.20	—	—	—	—	—	—	
" 4	"	The water was withdrawn for testing as in Experiment 1.	—	100	100	—	"	1.08	—	—	—	—	—	—	
" 5	"		—	100	100	—	"	1.08	—	—	—	—	—	—	
" 6	"		—	100	100	—	"	1.08	—	—	—	—	—	—	
" 7	"		—	100	100	—	"	0.98	—	—	—	—	—	—	
" 8	"		—	100	100	—	"	1.08	—	—	—	—	—	—	
" 9	"		—	100	100	—	"	1.20	—	—	—	—	—	—	
" 10	"		—	100	100	—	"	1.08	—	—	—	—	—	—	

Conditions same as in Experiment 1.  
The water was withdrawn for  
testing as in Experiment 1.



TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid withdrawn for Testing.	Amount of Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re-action with Lead mold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
4—cont	1886. May 19		Grms. 1,000 Settle peat.	c.c. 100	c.c. 100	—	Acid	0.60	—	—	—	—	—	—	
	" 20		—	100	100	—	"	0.66	—	—	—	—	—	—	
	" 21		—	100	100	—	"	0.72	—	—	—	—	—	—	
	" 22		—	100	100	—	"	0.78	—	—	—	—	—	—	
	" 23		—	100	100	—	"	0.78	—	—	—	—	—	—	
	" 24		—	100	100	—	"	0.96	—	—	—	—	—	—	
	" 25		—	100	100	—	"	0.96	—	—	—	—	—	—	
	" 26		—	100	100	—	"	1.08	—	—	—	—	—	—	
	" 27		—	100	100	—	"	1.20	—	—	—	—	—	—	
	" 28		—	100	100	—	"	1.28	—	—	—	—	—	—	
	" 29		—	100	100	—	"	1.20	—	—	—	—	—	—	
	" 30		—	100	100	—	"	1.28	—	—	—	—	—	—	
	" 31		—	100	100	—	"	1.28	—	—	—	—	—	—	
	June 1		—	100	100	—	"	1.32	—	—	—	—	—	—	
	" 3		—	100	100	—	"	1.28	—	—	—	—	—	—	
		Conditions same as Experiment 1. The water was withdrawn for testing as in Experiment 1, but as much $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ was added to the water replacing that withdrawn, as corresponded to the amount necessary to neutralise the water abstracted. Thus, if a 100 c.c. of the water withdrawn for testing required 0.15 $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ to neutralise it, then to the 100 c.c. of water replacing it 0.15 $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ was first added.													Owing to the addition of the $\text{Na}_2\text{CO}_3$ the peat water became gradually browner in colour, making the testing for acidity more and more difficult.



TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid withdrawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re-action with Lead-mold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
4— cont.	1895. June 26	Conditions same as Experiment 1. The water was withdrawn for testing, as in Experiment 1, but as much $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ was added to the water replacing that withdrawn, as corresponded to the amount necessary to neutralise	Gras. 1,000 Settle peat.	c.c. 100	c.c. 100	—	Acid	1·20	—	—	—	—	—	—	
"	" 27		—	100	100	—	"	1·20	—	—	—	—	—	—	
"	" 28		—	100	100	—	"	1·08	—	—	—	—	—	—	
"	" 29		—	100	100	—	"	1·08	—	—	—	—	—	—	
"	" 30		—	100	100	—	"	1·20	—	—	—	—	—	—	
July 1			—	100	100	—	"	1·08	—	—	—	—	—	—	
"	" 2		—	100	100	—	"	1·08	—	—	—	—	—	—	
"	" 3		—	100	100	—	"	1·20	—	—	—	—	—	—	
"	" 4		—	100	100	—	"	1·20	—	—	—	—	—	—	
"	" 5		—	100	100	—	"	1·08	—	—	—	—	—	—	
"	" 6		—	100	100	—	"	1·08	—	—	—	—	—	—	
"	" 7		—	100	100	—	"	0·96	—	—	—	—	—	—	
"	" 8		—	100	100	—	"	1·08	—	—	—	—	—	—	
"	" 9		—	100	100	—	"	1·20	—	—	—	—	—	—	
"	" 10		—	100	100	—	"	1·08	—	—	—	—	—	—	



TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid withdrawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re-action with Lac-mold.	Acidity in Terms of c.c. of $\frac{1}{10}$ $\text{N}_2\text{CO}_3$ required to neu-tralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Aver. age.	
5— cont	1895. July 13		Grms. 1,000 Settle peat.	c.c. 500	c.c. 500	—	Acid	0.72	0.1	0.2	0.3	0.4	0.5	0.30	
	" 20		—	500	1,000	—	"	0.84	0.1	0.2	0.3	0.4	0.3	0.26	
	" 27		—	500	1,000	—	"	0.78	0.1	0.2	0.3	0.3	0.4	0.26	
	Aug. 5		—	500	500	—	"	0.78	0.1	0.1	0.2	0.2	0.2	0.16	
	" 10		—	500	500	—	"	0.90	0.1	0.2	0.2	0.2	0.2	0.18	
	" 17		—	500	500	Present	"	0.78	0.1	0.2	0.2	0.2	0.2	0.18	
	" 24		—	500	500	Trace	"	0.78	0.1	0.1	0.2	0.1	0.1	0.12	
	" 31		—	500	500	Present	"	0.78	0.1	0.1	0.1	0.2	0.1	0.12	
	Sept. 7		—	500	500	"	"	0.84	0.0	0.1	0.1	0.1	0.1	0.06	
	" 14		—	500	500	"	"	0.78	0.1	0.1	0.2	0.2	0.2	0.16	
" 21		—	500	500	"	"	0.78	0.1	0.1	0.0	0.1	0.1	0.06		
" 28		—	500	500	"	"	0.84	0.0	0.1	0.3	0.3	0.3	0.26		
"	Oct. 5		—	500	—	Trace	"	0.78	0.0	0.1	0.1	0.1	0.1	0.06	

6	May 25	1,000 <sup>th</sup> Bottle peat.	7,800	Acid	—	The peat was obtained from nearby near Bottle.
26	100	100	0.84	—	—	—
27	100	100	0.80	—	—	—
28	100	100	0.86	—	—	—
29	100	100	0.46	—	—	—
30	100	100	0.46	—	—	—
31	100	100	0.54	—	—	—
June 1	100	100	0.66	—	—	—
2	100	100	0.66	—	—	—
3	100	100	0.60	—	—	—
4	100	100	0.60	—	—	—
5	100	100	0.66	—	—	—
6	100	100	0.78	—	—	—
7	100	100	0.78	—	—	—
8	100	100	0.78	—	—	—
9	100	100	0.84	—	—	—
10	100	100	0.78	—	—	—
11	100	100	0.78	—	—	—
12	100	100	0.78	—	—	—
13	100	100	0.72	—	—	—
14	100	100	0.72	—	—	—
15	100	100	0.72	—	—	—
16	100	100	0.72	—	—	—

Conditions same as in Experiments.  
The water was withdrawn for  
testing as in Experiment 1.



TABLE OXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re- action with Lead- mold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.	Action of Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Aver- age.
6— cont.	1896. June 17		Grms. 1,000 Settle peat.	c.c.	c.c.	—	Acid	0.72	—	—	—	—	—	—	
	" 18		—	100	100	—	"	0.72	—	—	—	—	—	—	
	" 19		—	100	100	—	"	0.72	—	—	—	—	—	—	
	" 20		—	100	100	—	"	0.66	—	—	—	—	—	—	
	" 21		—	100	100	—	"	0.66	—	—	—	—	—	—	
	" 22		—	100	100	—	"	0.60	—	—	—	—	—	—	
	" 23		—	100	100	—	"	0.60	—	—	—	—	—	—	
	" 24		—	100	100	—	"	0.60	—	—	—	—	—	—	
	" 25		—	100	100	—	"	0.66	—	—	—	—	—	—	
	" 26		—	100	100	—	"	0.72	—	—	—	—	—	—	
	" 27		—	100	100	—	"	0.66	—	—	—	—	—	—	
	" 28		—	100	100	—	"	0.72	—	—	—	—	—	—	
	" 29		—	100	100	—	"	0.66	—	—	—	—	—	—	
	" 30		—	100	100	—	"	0.66	—	—	—	—	—	—	
		July 1		—	100	100	—	"	0.72	—	—	—	—	—	—



TABLE CXXXIV.—continued.

Experiment	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re- action with Lac- moid.	Acidity in Terms of c.c. of $\text{Na}_2\text{CO}_3$ 10 required to neu- tralise 100 c.c. of the Water.	Action on Lead (Paris per 100,000). The action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Aver- age.	
6— cont	1895. Sept. 8	Grass. 1,000 Settle peat.	—	c.c. 700	c.c. 700	—	Acid	0·78	—	—	—	—	—	—	The peat was obtained from moorland near Settle.
	" 15	—	—	700	700	—	"	0·72	—	—	—	—	—	—	
	" 22	—	—	700	700	—	"	0·78	—	—	—	—	—	—	
	" 29	—	—	700	—	—	"	0·84	—	—	—	—	—	—	
7	May 25	1,000 Settle peat.	—	—	7,800	—	—	—	—	—	—	—	—	—	
	" 26	—	—	100	100	—	Acid	0·24	—	—	—	—	—	—	
	" 27	—	—	100	100	—	"	0·36	—	—	—	—	—	—	
	" 28	—	—	100	100	—	"	0·42	—	—	—	—	—	—	
	" 29	—	—	100	100	—	"	0·48	—	—	—	—	—	—	
	" 30	—	—	100	100	—	"	0·48	—	—	—	—	—	—	
	" 31	—	—	100	100	—	"	0·54	—	—	—	—	—	—	
	June 1	—	—	100	100	—	"	0·66	—	—	—	—	—	—	
	" 2	—	—	100	100	—	"	0·66	—	—	—	—	—	—	
	" 3	—	—	100	100	—	"	0·54	—	—	—	—	—	—	
	" 4	—	—	100	100	—	"	0·60	—	—	—	—	—	—	



TABLE CXXXIV.—continued.

Experiment	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount Neutral Distilled Water added to Contents of Cylinder.	Iron.	Re- action with Lac- moid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Aver- age.
7— cont.	1885. June 29	Conditions same as in Experiment 4. $\text{Na}_2\text{CO}_3$ was added to the water as in Experiment 4.	Grass, 1,000 Settle peat.	c.c. 100	c.c. 100	—	Acid	0.66	—	—	—	—	—	—	
" 30	—		100	100	—	"	0.66	—	—	—	—	—	—	—	
July 1	—		100	100	—	"	0.66	—	—	—	—	—	—	—	
" 2	—		100	100	—	"	0.73	—	—	—	—	—	—	—	
" 3	—		100	100	—	"	0.73	—	—	—	—	—	—	—	
" 4	—		100	100	—	"	0.73	—	—	—	—	—	—	—	
" 5	—		100	100	—	"	0.73	—	—	—	—	—	—	—	
" 6	—		100	100	—	"	0.73	—	—	—	—	—	—	—	
" 7	—		100	100	—	"	0.73	—	—	—	—	—	—	—	
" 8	—		100	100	—	"	0.78	—	—	—	—	—	—	—	
" 9	—		100	100	—	"	0.78	—	—	—	—	—	—	—	
" 10	—		100	100	—	"	0.73	—	—	—	—	—	—	—	
" 11	—		100	100	—	"	0.78	—	—	—	—	—	—	—	
" 12	—	100	100	—	"	0.84	—	—	—	—	—	—	—		
" 13	—	100	100	—	"	0.78	—	—	—	—	—	—	—		



TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Liquid drawn for Testing.	Amount of Iron.	Re-action with Lead-mold.	Acidity in Terms of c.c. of $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise the Water.	Action on Lead (Parts per 100,000). The action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Average.	Remarks.
								1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		
9	1895. May '98	Conditions same as Experiment 5. The water withdrawn was tested for plumbosolvency as well as for acidity, as in Experiment 5.	1,000 Shipley peat.	8,500	—	—	—	—	—	—	—	—	—	—
	June 4		—	500	Present	Acid	0.36	0.1	0.2	0.2	0.2	0.2	0.18	The peaty water gradually became so dark in colour that accurate testing was impossible, and the experiment had to be abandoned. The peat was obtained from the moorland gathering ground of the Shipley water supply.
	" 11		—	500	"	"	0.66	0.0	0.0	0.1	0.1	0.1	0.06	
	" 18		—	500	"	"	0.86	0.1	0.2	0.4	0.4	0.4	0.30	
	" 25		—	500	"	"	0.90	0.2	0.4	0.4	0.4	0.4	0.36	
	July 2		—	1,000	"	"	0.84	0.1	0.2	0.3	0.3	0.3	0.24	
	" 9		—	1,000	"	"	1.03	0.4	0.4	0.4	0.8	0.8	0.56	
	" 16		—	1,000	"	"	0.73	0.05	0.2	0.3	0.2	0.2	0.17	
	" 23		—	1,000	"	"	0.72	0.05	0.1	0.2	0.2	0.2	0.16	
	" 30		—	1,000	"	"	0.90	0.1	0.1	0.2	0.5	0.5	0.28	
	Aug. 6		—	1,000	"	"	1.0	0.1	0.1	0.4	0.4	0.4	0.28	
	" 13		—	1,000	"	"	1.2	Distinct action, but impossible to estimate, owing to dark colour of liquid.					—	
	June 4	Conditions same as in Experiment 9. Owing to an accident the experiment had to be abandoned.	1,000 Bentham peat.	7,750	—	—	—	—	—	—	—	—	—	—
10	June 4	Conditions same as in Experiment 9. Owing to an accident the experiment had to be abandoned.	1,000 Bentham peat.	7,750	—	—	—	—	—	—	—	—	—	—

[illegible]



TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount of Neutral Distilled Water added to Contents of Cy- linder.	Iron.	Re- action with Lac- moid.	Acidity in Terms of c.c. of $\frac{1}{N}$ Na <sub>2</sub> CO <sub>3</sub> required to neu- tralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Aver- age.
12— cont.	1895. Aug. 28	Grma. 1,000 Bradford peat.	1,000	1,000	1,000	Present	Acid	0.78	0.1	0.1	0.1	0.1	0.1	0.10	In this experi- ment river water was used instead of dis- tilled water. The peat was obtained from moorland near Settle.
	Sept. 4		1,000	1,000		"	"	0.72	0.1	0.2	0.2	0.2	0.1	0.16	
13	July 25	1,000 Settle peat.		8,000		—	—	—	—	—	—	—	—	—	
	Aug. 1		1,000	1,000	1,000	Present	Pt. acid	—	0.1	15	0.2	0.3	0.3	0.31	
	" 8		1,000	1,000	1,000	"	"	—	0.1	0.2	0.3	0.3	0.3	0.24	
	" 15		1,000	1,000	1,000	"	"	—	0.1	0.2	0.2	0.2	0.2	0.18	
	" 22		1,000	1,000	1,000	"	"	—	0.1	0.2	0.2	0.2	0.2	0.18	
	" 29		1,000	1,000	1,000	"	"	—	0.1	0.2	0.2	0.2	0.3	0.23	
	Sept. 5		1,000	1,000	1,000	"	Acid	—	0.2	0.2	0.2	0.2	0.3	0.20	
	" 12		1,000	1,000	1,000	"	"	—	0.1	0.3	0.4	0.4	0.4	0.33	
	" 19		1,000	1,000	1,000	"	"	—	0.0	0.1	0.2	0.2	0.3	0.18	
	" 26		1,000	1,000	1,000	"	"	—	0.1	0.2	0.2	0.3	0.3	0.23	
	Oct. 3		1,000	1,000	1,000	"	"	—	0.1	0.2	0.2	0.2	0.3	0.20	
	" 10		1,000	1,000	1,000	"	Pt. acid	—	0.0	0.1	0.1	0.1	0.1	0.08	

Date	Experiment	Peat	Weight	Temperature	pH	Acidity	Alkalinity	Specific Gravity	Conductivity	Resistivity	Dissolved Solids	Total Solids	Ash	Moisture	Notes
14 Aug. 31	24	100 Huddersfield peat.	1,000	—	—	—	—	—	—	—	—	—	—	—	Although only 100 grms. of peat were used in this experiment, the peaty water gradually became so dark in colour that accurate testing was impossible, and the experiment was at length abandoned.
" 28	28	"	1,000	—	—	—	—	—	—	—	—	—	—	—	The peat was obtained from the moorland gathering ground of the Huddersfield water supply.
Sept. 4	4	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 11	11	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 18	18	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 25	25	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
Oct. 2	2	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 9	9	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 16	16	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 23	23	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 30	30	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
Oct. 7	7	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 14	14	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 21	21	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
15 Aug. 30	30	1,000 Bradford peat.	1,000	—	—	—	—	—	—	—	—	—	—	—	
Sept. 2	2	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 9	9	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 16	16	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 23	23	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 30	30	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
Oct. 7	7	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 14	14	"	1,000	—	—	—	—	—	—	—	—	—	—	—	
" 21	21	"	1,000	—	—	—	—	—	—	—	—	—	—	—	

Conditions same as in Experiment 9. Distilled water again used. The water was withdrawn for testing as in previous experiments.

Conditions same as in Experiment 9, but Settle water (a hard limestone water) used instead of distilled water. The water was withdrawn for testing as in the previous experiments.

TABLE CXXXIV.—continued.

Experiment.	Date.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of the Liquid with- drawn for Testing.	Amount Neutral Water added to Contents of Cy- linder.	Iron.	Re- action with Lead mold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{N}_2\text{CO}_2$ required to neu- tralise the Water.	Action on Lead (Parts per 100,000) The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
									1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Aver- age.	
16	Sept. 9.	96.	Grms. 100 Halifax peat.	—	8,000	—	—	—	—	—	—	—	—	—	In this experi- ment, although only 100 grms. of peat were used, the peaty water became very dark in colour. The peat was obtained from the moorland gathering ground of the Halifax water supply. In this experi- ment rain- water was used instead of dis- tilled water. The peaty water became so dark in colour that the experiment had to be given up. The peat was obtained from the moor- land gathering ground of the Moosley water supply.
	" 16	Conditions same as in Experiment 9. Distilled water again used.	—	1,000	000	Nil	Acid	0.86	0.0	0.1	0.1	0.1	0.1	0.08	
	" 23	The water was withdrawn for testing as in the previous experi- ments.	—	1,000	1,000	"	"	0.66	0.0	0.3	0.2	0.3	0.2	0.20	
	" 30		—	1,000	1,000	"	"	0.66	0.0	0.1	0.2	0.2	0.2	0.14	
	Oct. 7		—	1,000	1,000	"	"	0.60	0.0	0.1	0.1	0.2	0.2	0.12	
	" 14		—	1,000	—	"	"	0.60	—	—	Traces.				
17	Oct. 22	260 Moosley peat.	—	—	8,000	—	—	—	—	—	—	—	—	—	In this experi- ment rain- water was used instead of dis- tilled water. The peaty water became so dark in colour that the experiment had to be given up. The peat was obtained from the moor- land gathering ground of the Moosley water supply.
	" 26		—	1,000	1,000	Trace	Acid	0.48	0.0	0.0	0.1	0.1	0.1	0.06	
	Nov. 5		—	1,000	1,000	"	"	0.66	0.0	0.0	0.1	0.1	0.1	0.06	
	" 12	Conditions same as in Experiment 9, but rain-water (neutral, and free from plumbic-solvent ability) used.	—	1,000	1,000	Nil	"	0.80	0.1	0.1	0.1	0.1	0.2	0.12	
	" 19	The water was withdrawn for testing as in the previous experi- ments.	—	1,000	1,000	Trace	"	0.80	0.2	0.2	0.2	0.2	0.3	0.22	
	" 26		—	1,000	1,000	"	"	0.60	0.1	0.1	0.3	0.3	0.3	0.22	
	Dec. 3		—	1,000	1,000	Nil	"	0.54	0.1	0.1	0.1	0.1	0.1	0.1	
	" 10		—	1,000	1,000	"	"	0.54	0.1	0.1	0.1	0.1	0.1	0.1	



# Plate. IV

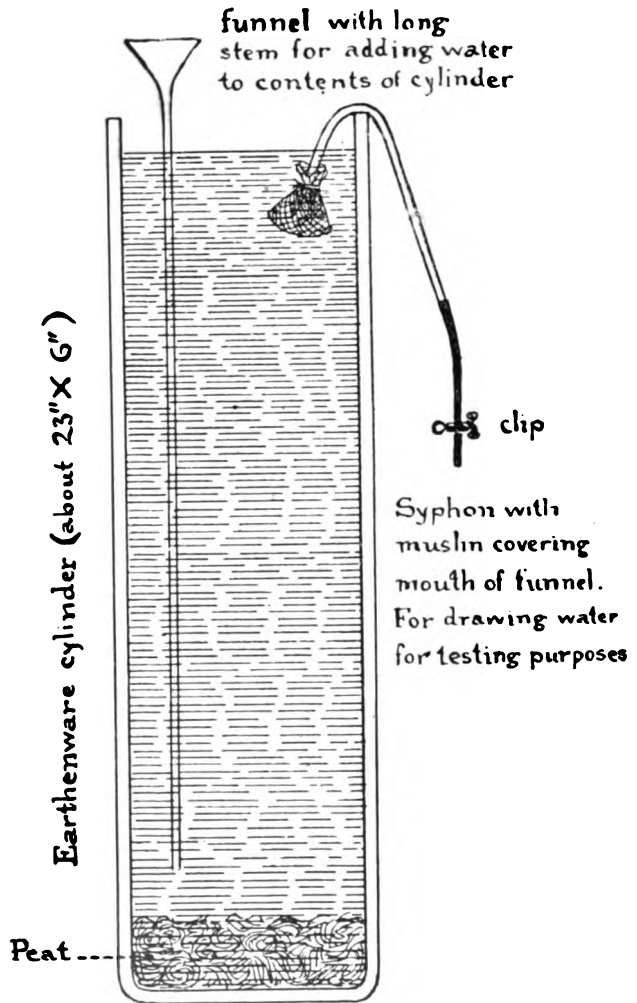


Fig 6  
[To illustrate  
Table CXXXIV

[To face page 287.]

The conditions of experiment are fully explained in the table (Table CXXXIV., Fig. 6, Plate IV.) It will be seen that the aim of the experiments was to imitate, as nearly as possible, the stagnation of rain-water in peat pools on moorland gathering grounds.

Experiment 1 shows that 500 grammes of Settle peat were able to confer acid and plumbo-solvent qualities on 11,350 c.c. of neutral non-plumbo-solvent distilled water. In other words, one part of peat sufficed to render at least 22 parts of water dangerous, as regards acidity and solvent action on lead.

Experiment 2 was a repetition of Experiment 1, except that the peat was tied up in muslin with the object of keeping thereby the water more clear for testing purposes. 500 grammes of peat rendered 10,275 c.c. of water acid and plumbo-solvent (one part of peat to at least 20 parts of water).

Experiment 3 was also a repetition of Experiment 1, but here 1,000 grammes of peat were used and the water was tested for acidity only. But the presence of acid implies, practically speaking, the possession as well of power to dissolve lead. Here 1,000 grammes of peat rendered acid 20,900 c.c. (one part of peat to at least 20 parts of water).

Experiment 4 differed from Experiment 1, inasmuch as when a given quantity of water was withdrawn for testing purposes, and the amount of  $\frac{n}{10}$   $\text{Na}_2\text{CO}_3$  necessary to neutralise it ascertained, a corresponding amount of  $\frac{n}{10}$   $\text{Na}_2\text{CO}_3$  was added to the water subsequently used to renew the supply in the cylinder. Thus, if 100 c.c. of the water withdrawn for testing required  $0.12 \frac{n}{10}$   $\text{Na}_2\text{CO}_3$  to effect neutralisation, then to the 100 c.c. of water replacing that withdrawn  $0.12 \frac{n}{10}$   $\text{Na}_2\text{CO}_3$  was first added. Owing to the addition of the  $\text{Na}_2\text{CO}_3$ , the peat water became gradually browner in colour, making the testing for acidity more and more difficult; even at the end of the experiment the peat water was distinctly acid in reaction. The total bulk of water made acid by the 1,000 grammes of peat was 18,100 c.c.

In Experiment 5 the plumbo-solvency of the peaty water as well as its acidity was tested. The cylinder leaked a little, so that sometimes the water added exceeded in amount that withdrawn for testing purposes. The results showed that 1,000 grammes of Settle peat could render acid and plumbo-solvent 21,250 c.c. of water (1 part of peat to at least 21 parts of water).

Experiment 6 resembled Experiments 1 and 3, and showed that 1,000 grammes of peat could render acid 19,800 c.c. of neutral water (1 part of peat to at least 19 parts of water).

Experiment 7 resembled Experiment 4; and the results obtained were very similar.

Experiment 8 resembled Experiment 5, except that Keighley peat was used. The colour of the peaty water gradually became so dark that accurate testing was impossible, and the experiment had to be

abandoned probably long before the peat had exhausted its acid-producing power. However, 1,000 grammes of Keighley peat conferred acid and plumbo-solvent properties on 19,250 c.c. of neutral water (1 part of peat to at least 19 parts of water).

In Experiment 9, Shipley peat was used. Here 1,000 grammes of peat made 19,500 c.c. of neutral water acid and possessed of plumbo-solvent power (1 part of peat to at least 19 parts of water).

Experiment 10 was a failure, owing to an accident.

In Experiment 11, Sheffield peat was used. Here 1,000 grammes of peat rendered acid and plumbo-solvent 21,500 c.c. of water (1 part of peat to at least 21 parts of water).

In Experiment 12, Bradford peat was used; 1,000 grammes of peat rendered 21,500 c.c. of a neutral water acid and plumbo-solvent (1 part of peat to at least 21 parts of water).

Experiment 13 differed from the preceding, inasmuch as Ribble water (a river water possessed of an appreciable degree of acid neutralising ability) was used instead of distilled water. Nevertheless, 1,000 grammes of Settle peat rendered 20,000 c.c. of the river water acid and possessed of plumbo-solvent ability.

In Experiment 14, Huddersfield peat was used. Here 100 grammes of peat conferred acid and plumbo-solvent properties on 16,000 c.c. of distilled water (1 part of peat to 160 parts of water).

In Experiment 15, Bradford peat and Settle water (a hard limestone water possessed of a considerable degree of acid-neutralising ability) were used. Notwithstanding the presence of lime salts, the peat conferred on the water a slight but appreciable power of dissolving lead.

In Experiments 16 and 17, Halifax and Mossley peat respectively were employed, and in Experiment 17 rain-water was used instead of distilled water. The results, as regards acidity and plumbo-solvent ability, were comparable to those already considered.

In the following table (Table CXXXV., see Fig. 7, Plate V.) the effect, as regards acidity and plumbo-solvent ability, of filtering non-plumbo-solvent distilled water intermittently through peat is shown :—

TABLE CXXXV.

Showing the EFFECT, as regards ACIDITY and PLUMBO-SOLVENT ABILITY, of FILTERING NON-PLUMBO-SOLVENT DISTILLED WATER through PEAT. The same Sample of Peat was used throughout the Experiments, but the Filtration was Intermittent—the Peat being allowed to rest between each Experiment. See Fig. 7, Plate V.

Experiment.	Date.	Description of the Experiment.	Reaction with Laccmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). Tested by downward Filtration (at the Rate of 3 mins. per 50 c.c.) through 50 c.c. washed Lead Shot.				
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c. Average.
1	1895. June 29th	100 grms. Bradford peat (from low level gathering ground) in double muslin filter. 1,000 c.c. boiled distilled water (neutral and free from plumbo-solvent acidity) filtered slowly through the peat, and the filtrate tested for acidity and plumbo-solvent ability.	Acid	0.72	0.5	0.8	0.8	0.9	0.70
2	July 1st	1,000 c.c. distilled water again filtered through the same peat	"	0.46	0.2	0.5	0.6	0.6	0.50
3	" 4th	"	"	0.80	0.1	0.3	0.4	0.4	0.30
4	" 6th	"	"	0.80	0.1	0.2	0.2	0.3	0.22
5	" 8th	"	"	0.80	0.1	0.2	0.2	0.2	0.18
6	" 10th	"	"	0.24	0.0	0.1	0.2	0.2	0.14
7	" 16th	"	"	0.80	0.1	0.2	0.2	0.3	0.22
8	" 23rd	"	"	0.36	0.2	0.5	0.6	0.6	0.50
9	Aug. 2nd	"	"	0.30	0.1	0.2	0.3	0.3	0.24



TABLE CXXXV.—continued.

Experiment.	Date.	Description of the Experiment.	Reaction with Læmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). Tested by downward Filtration (at the Rate of 3 mins. per 50 c.c.) through 50 c.c. washed Lead Shot.				
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c. Average.
10	1898. Aug. 16th	1,000 c.c. distilled water again filtered through the same peat. As the peat had gradually become pulpy and slimy in character, it was spread out on filter paper and allowed to become nearly air dry.	Very faintly acid.	0.30	0.0	0.0	0.1	0.1	0.06
11	" 21st	The peat (now nearly dry) was re-transferred to the muslin filter, and 1,000 c.c. water filtered through as previously.	Acid	0.30	0.1	0.1	0.2	0.2	0.16
12	" 28th	1,000 c.c. distilled water again filtered through the same peat	"	0.24	0.0	0.1	0.1	0.1	0.10
13	Sept. 7th	" " " " " "	"	0.24	0.0	0.1	0.1	0.1	0.10
14	" 17th	" " " " " "	"	0.30	0.0	0.1	0.2	0.3	0.20
15	" 27th	" " " " " "	"	0.24	0.1	0.1	0.2	0.2	0.16
16	Oct. 12th	Same as Experiment 10	"	0.24	0.0	0.1	0.1	0.1	0.10
17	Nov. 4th	Same as Experiment 11. After filtration, peat again dried as in Experiment 10	"	0.36	0.1	0.4	0.4	0.5	0.38
18	" 11th	Same as Experiment 11	"	0.30	0.0	0.1	0.2	0.2	0.18
19	Dec. 7th	1,000 c.c. distilled water again filtered through the same peat. After filtration peat again dried as in Experiment 10.	Faintly acid.	0.18	Traces				
20	" 14th	Same as in Experiment 11	Very faintly acid.	0.18	Traces				



# Plate V.

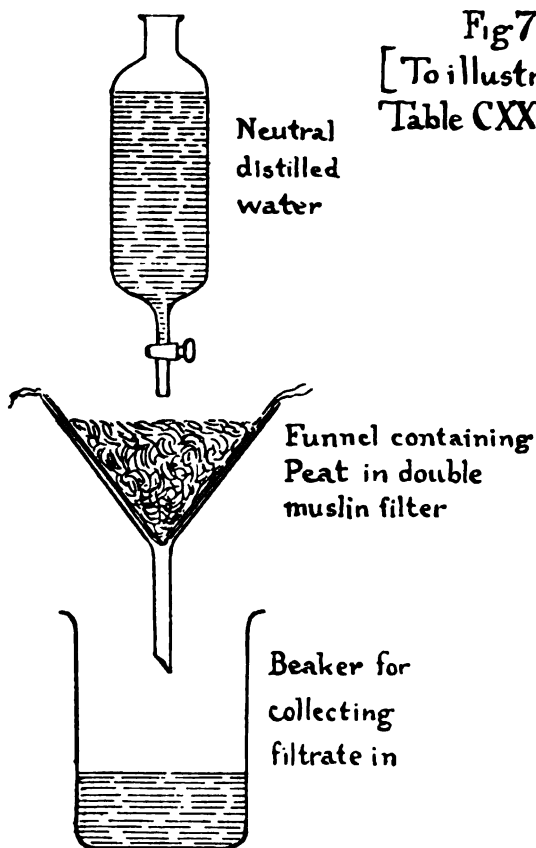


Fig 7  
[ To illustrate  
Table CXXXV ]

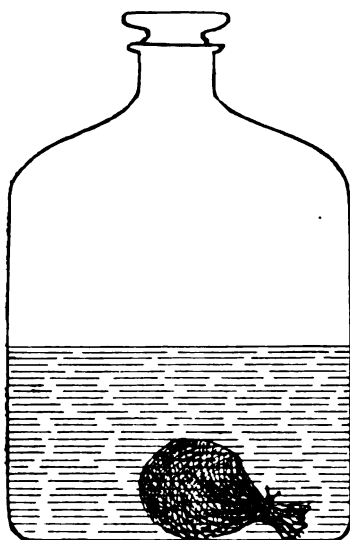


Fig 8  
[ To illustrate  
Table CXXXIX ]

Stoppedpered  
bottle with  
air space

500 c.c. neutral  
distilled water

10 grammes Peat  
tied up in muslin  
bag

The conditions of experiment are fully stated in the table (Table CXXXV., Fig. 7, Plate V.). The object of the experiments was to determine the degree of acidity and plumbo-solvent ability a definite quantity of peat was capable of conferring on a neutral water intermittently filtered through it. An attempt was also made to determine the utmost limit of this acid-producing power of the peat, and this object was achieved by repeated, but intermittent, filtration of relatively large quantities of water through the peat until the power of the latter to yield acid was practically entirely exhausted. It will be noted that, up to a certain point, the peat, with suitable intervals of rest, had a considerable power of imparting acid and plumbo-solvent qualities to a relatively large bulk of water filtered through it. Thus between June 29th and August 2nd, 1895 (Experiments 1 to 9), 9,000 c.c. of neutral water were rendered acid and plumbo-solvent by only 100 grammes of peat. Afterwards it became necessary, at intervals, to spread out the peat on filter paper to allow it to become nearly air-dry, before repeating the filtration process. This air-drying usually had the effect of restoring, to some extent, its diminished acid-producing power to the peat. Between August 16th and December 14th (Experiments 10 to 20) 11,000 c.c. of water were filtered through the peat. Altogether, the original 100 grammes of peat conferred on 20,000 c.c. of water acid and plumbo-solvent properties (1 part of peat to 200 parts of water). The acidity and plumbo-solvent ability of the filtrates tended (with intermissions) to become less and less as the filtration proceeded, but if all the separate filtrates had been mixed together, there can be no question but that the mixed water would have been capable of dissolving lead to a dangerous extent.

Table CXXXVI. shows the results of a somewhat similar series of peat filtration experiments. Here, only the acidity was tested for, and the filtrate was collected in successive loss of 100 c.c., and the filtration was usually continued until the filtrate was nearly neutral.

TABLE CXXXVI.  
Showing the EFFECT, as regards ACIDITY, of FILTERING BOILED DISTILLED WATER (Neutral) through PEAT.  
The same Peat was used throughout, but allowed to rest between each Experiment.

Experiment.	Date.	Description of Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water. Phenol-phthalein being used as indicator. The Reaction with Leacmoid is expressed by the letters d.a. (distinctly acid), f.a. (faintly acid), p.a. (p if very faintly acid or neutral), n. (neutral).										
			1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.
1	1895. July 6.	50 grms. Bradford peat (from the "low level" gathering ground) in double muslin filter. Boiled distilled water (neutral) filtered very slowly through the peat. Filtrate collected in successive lots of 100 c.c. and tested for acidity. Filtration usually continued until filtrate practically neutral.	1.3 d.a.	0.6 d.a.	0.48 d.a.	0.36 f.a.	0.36 f.a.	0.36 f.a.	0.24 p.a.	0.24 p.a.	0.24 p.a.	—	
2	" 11.	Boiled distilled water (neutral) again filtered through the same peat.	0.6 d.a.	0.36 d.a.	0.24 d.a.	0.24 f.a.	0.20 p.a.	—	—	—	—	—	
3	" 17.	" " " "	0.6 d.a.	0.48 d.a.	0.36 f.a.	0.24 f.a.	0.30 f.a.	0.24 p.a.	0.24 f.a.	—	—	—	
4	" 26.	" " " "	0.6 d.a.	0.4 d.a.	0.36 d.a.	0.30 d.a.	0.24 p.a.	0.30 f.a.	0.30 f.a.	—	—	—	
5	Aug. 2.	" " " "	0.3 d.a.	0.24 f.a.	0.24 f.a.	0.24 f.a.	0.24 p.a.	0.24 p.a.	0.24 p.a.	—	—	—	
6	" 17.	Boiled distilled water (neutral) again filtered through the same peat. As the peat had gradually become so pulpy and slimy in character as to interfere with the filtration, it was taken out and spread on filter paper so as to become air-dry.	0.24 f.a.	0.20 p.a.	0.20 p.a.	—	—	—	—	—	—	—	

7	" 23 -	The peat (now nearly dry) was re-transferred to the muslin, and distilled water filtered through as previously.	0'36 f.a.	0'40 d.a.	0'36 f.a.	-	-	-	-	-	-	-	-	-	-	-	-
8	" 27 -	Boiled distilled (neutral) water again filtered through the same peat.	0'40 d.a.	0'30 f.a.	0'18 p.a.	-	-	-	-	-	-	-	-	-	-	-	-
9	Sept. 6	" " " "	0'46 f.a.	0'40 f.a.	0'30 f.a.	0'30 p.a.	-	-	-	-	-	-	-	-	-	-	-
10	" 14	" " " "	0'18 f.a.	0'18 f.a.	0'18 p.a.	0'18 p.a.	-	-	-	-	-	-	-	-	-	-	-
11	" 21	" " " "	0'30 d.a.	0'24 d.a.	0'18 f.a.	0'18 p.a.	-	-	-	-	-	-	-	-	-	-	-
12	Oct. 3 -	" " " "	0'18 f.a.	0'24 f.a.	0'18 f.a.	0'18 p.a.	-	-	-	-	-	-	-	-	-	-	-
13	" 21 -	Same as Experiment 6	0'18 f.a.	0'18 f.a.	0'18 p.a.	0'18 p.a.	-	-	-	-	-	-	-	-	-	-	-
14	Nov. 5 -	Same as Experiment 7. After filtration peat again dried as in Experiment 6.	0'36 d.a.	0'36 d.a.	0'30 d.a.	-	-	-	-	-	-	-	-	-	-	-	-
15	" 9 -	Same as Experiment 7	0'36 d.a.	0'24 d.a.	0'18 d.a.	-	-	-	-	-	-	-	-	-	-	-	-
16	Dec. 7 -	Boiled distilled water (neutral) again filtered through the same peat.	0'18 d.a.	0'18 d.a.	0'18 p.a.	0'18 p.a.	-	-	-	-	-	-	-	-	-	-	-
17	" 16 -	" " " "	0'13 n.	0'12 n.	0'13 n.	0'12 n.	-	-	-	-	-	-	-	-	-	-	-

It will be observed that in each experiment the acidity in the first instance usually diminished with each successive 100 c.c. of filtrate collected and tested, until finally it became barely appreciable. But after resting the peat for some time there was evidence of a decided return of the acidity, not necessarily to the full extent observed in the corresponding filtrate of the preceding experiment, but nearly always considerably in excess of that noted in the last lot of filtrate from the previous experiment. As the experiment went on, the acidity of the filtrate gradually became less and less until it was no longer appreciable. If the results obtained from these experiments were expressed as a curve, then such a curve would have a general tendency in a downward direction, both considered as a whole and in relation to each separate filtration experiment; but the commencement of each individual experiment would be usually indicated by a rise, consequent to the resting of the peat. Judging the results as a whole, it may be said that 50 grammes of peat may be capable of rendering acid 8,800 c.c. of neutral water (1 part of peat to 176 parts of water). The experiments, of course, were designed to imitate, as nearly as possible, the conditions prevailing on moorland gathering grounds, when the rain saturates the peat and percolates through it, and when each successive rainfall washes out of the peat acid substances presumably manufactured *in situ*. The seeming ability of the peat, under conditions of rest and aeration, to manufacture fresh acid is an instructive feature of the above series of experiments.

The following table (Table CXXXVII.) shows the effect, as regards acidity and plumbo-solvent ability, of filtering water intermittently through peat:—

TABLE OXXXVII.

Showing the EFFECT, as regards ACIDITY and PLUMBO-SOLVENT ABILITY, of filtering WATER intermittently through PEAT. A double layer of muslin was placed in a large funnel, and the peat packed inside. Water was then started dropping slowly on to the peat in the funnel. A small piece of filter paper was put on the surface of the peat to spread the water dropping in. The water, after filtering through the peat, was collected in a suitable vessel and periodically examined for acidity and plumbo-solvent ability.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lacomoid.	Acidity in Terms of c.c. of $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1	Experiment started 3 p.m. July 18th, 1886. Distilled water, which had been previously boiled, and which was neutral and free from plumbo-solvent ability, filtered slowly through the peat.	grms. 500 grms. Bradford peat.	c.c. —	—	—	—	—	—	—	—	The sample of peat was obtained from Bradford moorland gathering ground. The filtrate was occasionally tested for iron. Sometimes faint traces were present. In all the experiments phenolphthalein was used as indicator in estimating the amount of the acidity.
3	" " 20th "	—	1,850	Acid	0.6	0.4	0.8	0.9	0.9	0.9	
3	" " 21st "	—	2,330	"	0.6	0.2	0.8	0.8	0.8	0.9	
3	" " 22nd "	—	2,980	"	0.66	0.4	0.6	0.7	0.7	0.7	
3	" " 23rd "	—	2,170	"	0.54	0.1	0.3	0.3	0.4	0.4	
3	" " 24th "	—	2,160	"	0.48	0.1	0.3	0.3	0.3	0.3	
3	" " 25th "	—	1,720	"	0.36	0.1	0.3	0.3	0.4	0.4	
			1,250	"	0.36	0.1	0.3	0.3	0.3	0.3	



TABLE CXXXVII.—*continued.*

Experiment.	Description of the Experiment.	Amount of Peat in the funnel.	Amount of Water filtered through the Peat.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
1— cont.	3 p.m., July 26th, 1895	—	gms. 1,450	Acid	0.36	0.1	0.3	0.3	0.3	0.3	0.26	It is to be noted that after the peat had been allowed to rest for some time, the acidity and plumbosolvent ability of the filtrate was increased.
	3 " " 27th "	—	1,250	"	0.36	0.1	0.2	0.3	0.3	0.3	0.24	
	3 " " 28th "	—	950	"	0.36	0.1	0.3	0.3	0.4	0.4	0.30	
	12 noon, July 28th, 1895	—	1,300	"	0.30	0.1	0.2	0.3	0.3	0.3	0.24	
	12 " " 30th "	—	1,350	"	0.30	0.05	0.2	0.2	0.2	0.3	0.19	
	12 " " 31st "	—	2,000	—	—	—	—	—	—	—	—	
	12 " August 1st, 1895	—	2,300	Acid	0.30	0.0	0.2	0.2	0.2	0.3	0.16	
	12 " " 2nd "	—	2,300	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08	
	From August 2nd to August 9th peat rested, to see if the acidity and plumbosolvent ability would thereby be increased.											
	12 noon, August 10th, 1895	—	1,650	Acid	0.54	0.1	0.3	0.3	0.5	0.4	0.32	
	12 " " 11th "	—	1,750	"	0.42	0.2	0.4	0.4	0.4	0.5	0.38	
	12 " " 12th "	—	1,650	"	0.30	0.1	0.1	0.1	0.1	0.1	0.10	
	12 " " 13th "	—	1,350	"	0.30	0.1	0.1	0.1	0.1	0.1	0.10	
	12 " " 14th "	—	1,170	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08	



TABLE CXXXVII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Leomold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of this Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1— cont.	13 noon, September 23rd, 1895	grms. —	c.c. 1,000	Acid	0.30	0.0	0.1	0.2	0.2	0.3	0.16
	13 " " 24th "	—	1,550	"	0.36	0.1	0.2	0.2	0.2	0.3	0.20
	12 " " 26th "	—	2,000	"	0.42	0.0	0.1	0.1	0.1	0.1	0.03
	12 " " 26th "	—	800	"	0.36	0.2	0.1	0.2	0.2	0.2	0.18
	13 " " 27th "	—	1,150	"	0.30	0.1	0.2	0.2	0.2	0.2	0.18
	13 " " 28th "	—	900	"	0.42	0.1	0.3	0.3	0.3	0.2	0.24
	12 " " 29th "	—	1,150	"	0.36	0.1	0.2	0.2	0.2	0.2	0.18
	12 " " 30th "	—	1,100	"	0.30	0.0	0.1	0.2	0.1	0.2	0.13
	13 " " 1st "	—	1,350	"	0.46	0.1	0.2	0.3	0.4	0.4	0.23
	12 " " 2nd "	—	1,100	"	0.24	0.0	0.1	0.2	0.2	0.2	0.14
	13 " " 3rd "	—	1,700	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08
	From October 3rd to 14th peat given a rest as previously.										
	13 noon, October 15th, 1895	—	1,000	"	0.48	0.1	0.4	0.4	0.5	0.5	0.23
	13 " " 16th "	—	1,000	"	0.24	0.0	0.2	0.2	0.2	0.3	0.18

12	"	"	17th	"	—	1,600	"	0.24	0.0	0.1	0.1	0.1	0.1	0.08
12	"	"	18th	"	—	800	"	0.24	0.0	0.1	0.1	0.2	0.10	
12	"	"	19th	"	—	1,200	Pt. acid	0.18	0.0	0.1	0.1	0.0	0.04	
From October 19th to 27th peat given a rest as above.														
12 noon, October 28th, 1895					—	1,500	Acid	0.20	0.0	0.1	0.1	0.1	0.1	0.08
12	"	"	29th	"	—	1,470	Pt. acid	0.20	0.0	0.0	0.1	0.1	0.04	
12	"	"	30th	"	—	1,550	"	0.18	0.0	0.0	0.1	0.1	0.04	
October 30th to November 12th. During this period the peat was removed from the funnel and spread out on filter paper. When nearly air dry, it was re-transferred to the funnel.														
12 noon, November 13th, 1895					—	600	Acid	0.72	1.2	1.6	2.0	2.0	1.68	
12	"	"	14th	"	—	900	"	0.48	0.1	0.2	0.3	0.3	0.22	
12	"	"	15th	"	—	900	"	0.30	0.0	0.1	0.2	0.3	0.16	
12	"	"	16th	"	—	900	"	0.30	0.0	0.1	0.2	0.3	0.16	
12	"	"	17th	"	—	1,200	"	0.24	0.0	0.1	0.1	0.1	0.08	
12	"	"	18th	"	—	1,100	"	0.24	0.0	0.1	0.1	0.1	0.06	
From November 18th to December 3rd peat given a rest.														
12 noon, December 4th, 1895					—	1,100	Acid	0.42	0.1	0.2	0.3	0.4	0.24	
12	"	"	5th	"	—	600	"	0.36	0.0	0.1	0.2	0.2	0.14	
12	"	"	6th	"	—	600	"	0.30	0.0	0.1	0.1	0.2	0.12	
12	"	"	7th	"	—	1,200	"	0.24	0.0	0.1	0.1	0.1	0.08	
12	"	"	8th	"	—	1,500	Pt. acid	0.18	0.0	0.0	0.1	0.1	0.06	

TABLE CXXXVII.—continued.

Experiment	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lœmoid.	Acidity in Terms of c.c. 10 Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
1— cont.	12 noon, December 9th, 1895	—	500	Pt. acid	0.18	0.0	0.0	0.1	0.1	0.1	0.06	} The filtrate was dark in colour, making testing difficult.  The colour of the filtrate was dark.
	From December 9th to December 18th peat given a rest.	—	580	Acid	0.48	0.1	0.2	0.2	0.2	0.2	0.18	
	12 noon, December 19th, 1895	—	500	"	0.48	Traces						
	12 " " 20th "	—	500	Pt. acid	0.24	? traces						
	12 " " 21st "	—	500									
	December 31st to December 28th. During this period the peat was spread out on filter paper. When nearly all dry it was re-transferred to funnel.											
	12 noon, December 29th, 1895	—	500	Acid	0.30	0.1	0.2	0.3	0.3	0.3	0.24	
	12 " " 30th "	—	500	"	0.24	0.05	0.1	0.1	0.2	0.2	0.13	
	December 30th, 1895, to January 2nd, 1896. During this period peat dried and new muslin put in funnel.											
	12 noon, January 3rd, 1896	—	700	Acid	0.30	0.05	0.1	0.1	0.15	0.2	0.13	
12 " " 4th "	—	750	Pt. acid	0.24	0.05	0.05	0.05	0.1	0.1	0.07		

12	"	"	5th	-	-	2,000	V. ft. acid	0'12				Traces.					
12	"	"	6th	-	-	800	Ft. acid	0'18	0'0	0'0	0'0	0'05	0'1	0'1	0'03		
12	"	"	7th	-	-	1,000	"	0'24	0'04	0'1	0'3	0'3	0'3	0'3	0'15		
From January 7th to 4th peat given a rest.																	
12	noon,	January	26th, 1896	-	-	500	"	0'18				Traces.					
12	"	"	26th "	-	-	500	V. ft. acid	0'12				† traces.					
From January 26th to February 1st, 1896, peat given a rest.																	
12	noon,	February	2nd, 1896	-	-	500	Ft. acid	0'18	0'0	0'05	0'1	0'1	0'1	0'1	0'07		
12	"	"	3rd "	-	-	500	† neutral	0'12				Traces.					
From February 3rd to February 9th peat given a rest.																	
12	noon,	February	10th, 1896	-	-	500	V. ft. acid	0'18	0'0	0'0	0'0	0'05	0'1	0'1	0'03		
12	"	"	11th "	-	-	500	† neutral	0'18				Traces.					
From February 11th to February 17th peat given a rest.																	
12	noon,	February	18th, 1896	-	-	500	Acid	0'30	0'05	0'3	0'2	0'3	0'3	0'3	0'21		
12	"	"	19th "	-	-	500	Ft. acid	0'24	0'05	0'1	0'1	0'3	0'3	0'3	0'13		
From February 19th to 26th peat given a rest.																	
12	noon,	February	26th, 1896	-	-	700	V. ft. acid	0'18	0'0	0'05	0'05	0'05	0'1	0'1	0'05		On February 27th, 1896, Experiment 1 was abandoned.
12	"	"	27th "	-	-	1,000	† neutral	0'18				Traces.					
Experiment started 12 noon August 4th, 1896. Conditions same as in Experiment 1.																	
2							300 grms. Huddersfield peat.		-	-	-	-	-	-	-	-	The sample of peat was obtained from the Huddersfield moorland gathering ground.

TABLE OXXXVII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat filtered in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Leornoid.	Acidity in Terms of c.c. $\frac{\%}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
2— cont.	13 noon, August 5th, 1895	—	c.c.	Acid	0.68	0.8	1.6	1.6	1.6	2.0	1.83	The filtrate was occasionally tested for iron. Traces were sometimes detected.  It is to be noted that after the peat had been tested, the acidity and plumbic-solvent ability of the filtrate were increased.
	6 " " 6th " " "	—	1,780	"	0.38	0.2	0.2	0.4	0.6	0.6	0.40	
	7 " " 7th " " "	—	1,680	"	0.24	0.1	0.2	0.2	0.2	0.3	0.20	
	8 " " 8th " " "	—	1,900	V. ft. acid	0.18	0.1	0.2	0.2	0.2	0.2	0.18	
	9 " " 9th " " "	—	1,680	"	0.18	0.0	0.1	0.1	0.1	0.1	0.08	
	August 9th to 19th peat given a rest, to see if acidity and plumbic-solvent ability would be thereby increased.	—	—	—	—	—	—	—	—	—	—	
	13 noon, August 20th, 1895	—	1,680	Acid	0.20	0.1	0.4	0.5	0.6	0.6	0.44	
	12 " " 21st " " "	—	1,600	"	0.20	0.1	0.2	0.3	0.3	0.3	0.24	
	13 " " 22nd " " "	—	1,400	"	0.20	0.0	0.1	0.1	0.2	0.2	0.13	
	13 " " 23rd " " "	—	1,400	Ft. acid	0.20	0.0	0.0	0.0	0.1	0.1	0.04	
	From August 23rd. to September 2nd peat given a rest.	—	—	—	—	—	—	—	—	—		
	13 noon, September 3rd, 1895	—	800	Acid	0.20	0.1	0.1	0.2	0.2	0.2	0.16	
	13 " " 4th " " "	—	800	"	0.20	0.0	0.1	0.1	0.2	0.2	0.13	

12	"	"	5th	-	680	"	0.24	0.0	0.1	0.1	0.1	0.1	0.08
12	"	"	6th	-	1,180	Pt. acid	0.18	0.0	0.0	0.1	0.1	0.1	0.06
From September 6th to 17th peat given a rest.													
12	noon,	September 18th,	1895	-	850	Acid	0.20	0.1	0.2	0.3	0.3	0.3	0.24
12	"	"	19th	"	1,100	"	0.24	0.0	0.1	0.1	0.1	0.2	0.10
12	"	"	20th	"	750	"	0.20	0.0	0.1	0.1	0.1	0.2	0.10
12	"	"	21st	"	1,450	Pt. acid	0.20	0.0	0.1	0.1	0.1	0.1	0.06
From September 21st to October 10th peat given a rest.													
12	noon,	October 11th,	1895	-	950	Acid	0.24	0.0	0.1	0.1	0.1	0.2	0.10
12	"	"	12th	"	1,200	"	0.24	0.0	0.1	0.1	0.1	0.1	0.06
12	"	"	13th	"	1,150	Pt. acid	0.18	0.1	0.1	0.1	0.1	0.1	0.10
12	"	"	14th	"	1,100	Acid	0.20	0.0	0.1	0.1	0.1	0.1	0.06
From October 14th to 24th, peat given a rest.													
12	noon	October 25th,	1895	-	1,350	Acid	0.20	0.0	0.1	0.1	0.1	0.1	0.06
12	"	"	26th	"	850	Pt. acid	0.18	0.0	0.0	0.1	0.1	0.1	0.06
12	"	"	27th	"	1,800	? neutral	0.12			Traces.			
From October 27th to November 3rd peat given a rest.													
12	noon,	November 4th,	1895	-	1,500	V. ft. acid	0.18			Traces.			
12	"	"	5th,	"	1,000	"	0.18			Traces.			
November 5th to 18th. During this period peat was removed from funnel and spread on filter paper. When nearly air dry it was retransferred to funnel.													



TABLE CXXXXVII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lœmold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.	
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
2— cont.	12 noon, November 19th, 1895	—	1,200	Acid	0.42	0.1	0.1	0.2	0.3	0.4	0.23	
	12 " " 20th "	—	650	"	0.30	0.0	0.1	0.1	0.2	0.2	0.12	
	12 " " 21st "	—	1,200	"	0.24	0.0	0.1	0.2	0.2	0.2	0.14	
	12 " " 22nd "	—	500	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08	
	12 " " 23rd "	—	1,000	"	0.20	0.1	0.1	0.1	0.1	0.1	0.10	
	From November 22nd to December 9th peat given a rest.	—	—	—	—	—	—	—	—	—	—	
	12 noon, December 10th, 1895	—	1,600	Acid	0.24	0.0	0.1	0.1	0.1	0.2	0.10	
	12 " " 11th "	—	550	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08	
	12 " " 12th "	—	1,050	V. ft. acid	0.18	0.0	0.0	0.0	0.1	0.1	0.04	
	From December 12th to 21st peat was given a rest.	—	—	—	—	—	—	—	—	—	—	
	12 noon, December 22nd, 1895	—	500	Acid	0.18	1.1	0.3	0.3	0.3	0.3	0.18	
	12 " " 23rd "	—	1,200	V. ft. acid	0.12	Traces.					Traces.	
	12 " " 24th "	—	1,300	"	0.12	Traces.						



TABLE CXXXVII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 5 mins. per 50 c.c.					Remarks.
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
2— cont.	12 noon, February 22nd, 1896	—	c.c. 700	? neutral	0·12			Traces.			On March 3rd, 1896, Experiment 2 was abandoned.  The sample of peat was obtained from moorland near Settle. It is to be noted that in this experiment only 150 grms. of peat were used. The filtrate was occasionally tested for iron. Sometimes faint traces were present.
	12 " " 23rd "	—	800	"	0·12			Traces.			
3	From February 23rd to March 1st peat given a rest.										
	12 noon, March 2nd, 1896	—	500	? neutral	0·12			Traces.			
	12 " " 3rd "	—	500	"	0·12			Traces.			
	Experiment started 12 noon, August 14th, 1896. Conditions same as in Experiment 1.	150 grms. Settle peat.	—								
	12 noon, August 15th, 1896	—	6,250	Acid	0·60	0·4	0·8	1·2	1·2	1·6	
	12 " " 16th "	—	1,080	"	0·30	0·1	0·2	0·2	0·3	0·3	
	12 " " 17th "	—	1,070	"	0·30	0·0	0·1	0·2	0·3	0·3	
	12 " " 18th "	—	900	"	0·24	0·0	0·1	0·1	0·2	0·2	
	12 " " 19th "	—	650	"	0·24	0·0	0·1	0·2	0·2	0·2	
	From August 16th to 30th, peat given a rest, to see if acidity and plumbo-solvent ability would thereby be increased.										

13 noon, August 31st, 1893	1,100		0.1	0.4	0.6	0.6	0.6	0.46
13 " September 1st, 1893	1,400	"	0.1	0.3	0.3	0.3	0.3	0.18
13 " " 2nd "	2,100	Ft. acid	0.0	0.0	0.0	0.1	0.1	0.04
From September 2nd to 14th peat given a rest as above.								
12 noon, September 16th, 1893	1,500	Acid	0.1	0.1	0.2	0.3	0.3	0.20
12 " " 16th "	1,600	Ft. acid	0.0	0.0	0.1	0.1	0.1	0.06
12 " " 17th "	800	"	0.0	0.0	0.1	0.1	0.1	0.06
September 17th to October 3rd peat again rested.								
12 noon, October 4th, 1893	1,700	Acid	0.1	0.1	0.1	0.2	0.2	0.14
12 " " 5th "	1,100	"	0.0	0.1	0.1	0.1	0.2	0.10
12 " " 6th "	1,100	Ft. acid	0.0	0.0	0.1	0.1	0.1	0.06
October 6th to 20th peat again rested.								
12 noon, October 21st, 1893	1,500	Acid	0.0	0.1	0.1	0.0	0.1	0.06
12 " " 22nd "	1,500	Ft. acid			Traces.			
October 22nd to 30th peat again rested.								
12 noon, October 31st, 1893	1,000	Ft. acid			Traces.			
October 31st to November 5th. During this period peat removed from funnel and spread on filter paper. When nearly air dry, it was retransferred to the funnel.								
12 noon, November 6th, 1893	900	Acid	0.1	0.2	0.2	0.1	0.3	0.16

It is to be noted that after the peat had been allowed to rest for some time, there was an increase in the acidity and plumbic-solvent ability of the filtrate.

TABLE CXXXVII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lœmold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
3— cont.	12 noon, November 7th, 1895	—	c.c. 1,600	Ft. acid	0·13	0·0	0·0	0·0	0·1	0·04	
	November 7th to 23rd peat again rested.										
	12 noon, November 24th, 1895	—	1,400	Acid	0·30	0·1	0·2	0·3	0·3	0·24	
	12 " " 25th "	—	1,400	Ft. acid	0·20	0·0	0·1	0·1	0·1	0·06	
	12 " " 26th "	—	700	Acid	0·30	0·1	0·2	0·3	0·3	0·24	
	12 " " 27th "	—	1,400	Acid	0·20	0·0	0·1	0·1	0·1	0·08	
	12 " " 28th "	—	1,400	Ft. acid	0·18	0·0	0·0	0·1	0·1	0·06	
	November 28th to December 12th peat again rested.										
	12 noon, December 13th, 1895	—	500	Acid	0·30	0·1	0·2	0·3	0·3	0·26	
	12 " " 14th "	—	500	"	0·24	0·1	0·1	0·2	0·2	0·16	
	12 " " 16th "	—	1,100	? neutral	0·12			Traces.			
	December 16th to 24th peat again rested.										
	12 noon, December 25th, 1895	—	500	Acid	0·24	0·05	0·1	0·1	0·2	0·15	

19	"	"	26th	"	-	500	Ft. acid	0.18	0.05	0.1	0.1	0.2	0.1	0.09
19	"	"	27th	"	-	500	"	0.18	0.05	0.05	0.1	0.1	0.1	0.05
19	"	"	28th	"	-	600	? neutral	0.19		Traces.				
December 28th, 1896, to January 14th, 1896. During this period peat removed from funnel, and spread out on filter paper. When nearly air dry the peat was re-transferred to funnel.														
19	noon,	January 15th, 1896		-		500	Acid	0.24	0.05	0.1	0.1	0.1	0.1	0.09
19	"	16th	"	-		750	Ft. acid	0.18	0.0	0.0	0.5	0.1	0.1	0.05
January 16th to 30th peat again rested.														
19	noon,	January 31st, 1896		-		650	"	0.18	0.0	0.05	0.1	0.1	0.1	0.07
19	"	February 1st	"	-		600	? neutral	0.19		? traces.				
February 1st to 7th peat again rested.														
19	noon,	February 8th, 1896		-		500	Acid	0.30	0.0	0.05	0.1	0.2	0.2	0.11
19	"	9th	"	-		500	? neutral	0.19		Traces.				
February 9th to 16th peat again rested.														
19	noon,	February 16th, 1896		-		500	Acid	0.30	0.1	0.05	0.1	0.2	0.2	0.16
19	"	17th	"	-		500	Ft. acid	0.18	0.05	0.1	0.1	0.1	0.1	0.09
February 17th to 23rd peat again rested.														
19	noon,	February 24th, 1896		-		850	"	0.20	0.5	0.1	0.1	0.1	0.1	0.09
19	"	25th	"	-		950	Neutral	0.12		? traces.				

On February 25th, 1896, Experiment 3 was abandoned.

TABLE CXXXVII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
4	Experiment started 13 noon October 6th, 1895. Conditions same as in Experiment 1.	150 grms. Mossley peat.	—	—	—	—	—	—	—	—	—	The sample of peat was obtained from the moorland gathering ground of Mossley water-supply. The filtrate was occasionally tested for iron. Its presence was not, however, detected.
	12 noon, October 7th, 1895.	—	1,550	Acid	0.43	0.3	0.5	0.7	0.7	0.9	0.63	
	13 " " 8th " "	—	1,500	"	0.20	0.05	0.1	0.1	0.2	0.2	0.13	
	13 " " 9th " "	—	1,100	"	0.20	0.1	0.1	0.1	0.2	0.2	0.14	
	13 " " 10th " "	—	1,200	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08	
	October 10th to 23rd peat given a rest, to see if acidity and plumbic solvent ability would be increased.	—	1,700	"	0.18	0.0	0.1	0.1	0.1	0.1	0.08	
	13 noon, October 23rd, 1895.	—	2,000	"	0.18	0.0	0.0	0.1	0.1	0.1	0.06	
	15 " " 24th " "	—	—	—	—	—	—	—	—	—	—	
	October 24th to 31st peat given a rest.	—	500	Pt. acid	0.24	0.0	0.0	0.1	0.1	0.1	0.06	
	12 noon, November 1st, 1895.	—	1,300	"	0.12	Traces.						
	12 " " 2nd " "	—	960	"	0.18	0.0	0.0	0.0	0.1	0.1	0.4	
	12 " " 3rd " "	—	—	—	—	—	—	—	—	—	—	
	November 3rd to 7th. During this period peat removed from funnel and spread out on filter paper. When nearly air dry the peat was re-transferred to funnel.	—	—	—	—	—	—	—	—	—	—	

At noon, November 8th, 1895	600	Acid	0.48	0.2	0.3	0.3	0.4	0.28
13 " " 9th "	1,000	"	0.24	0.0	0.1	0.1	0.2	0.10
13 " " 10th "	1,100	"	0.20	0.0	0.1	0.1	0.2	0.10
13 " " 11th "	1,800	Pt. acid	0.18	0.0	0.0	0.1	0.2	0.08
13 " " 12th "	1,200	V. ft. acid	0.18	0.0	0.0	0.0	0.1	0.04
November 12th to 28th peat given a rest.								
12 noon, November 26th, 1895	600	Acid	0.48	0.2	0.2	0.2	0.3	0.24
13 " " 30th "	550	"	0.36	0.1	0.1	0.2	0.2	0.16
13 " December 1st "	500	"	0.36	0.0	0.1	0.1	0.2	0.12
12 " " 2nd "	700	Pt. acid	0.18	0.0	0.05	0.1	0.1	0.07
12 " " 3rd "	600	"	0.18	0.0	0.05	0.1	0.1	0.07
December 3rd to 18th peat given a rest.								
12 noon, December 16th, 1895	500	Acid	0.30	0.1	0.2	0.2	0.3	0.20
13 " " 17th "	500	V. ft. acid			Traces.			
13 " " 18th "	500	"			Traces.			
December 18th, 1895, to January 16th, 1896. During this period peat removed from funnel and spread out on filter paper. When nearly air dry the peat was retransferred to funnel.								
12 noon, January 17th, 1896	1,350	Acid	0.24	0.1	0.1	0.1	0.2	0.14
12 " " 18th "	700	"	0.36	0.1	0.2	0.2	0.2	0.18
13 " " 19th "	500	V. ft. acid	0.18		Traces.			
13 " " 20th "	700	? neutral	0.12		? traces.			
January 20th to 26th peat given a rest.								



TABLE OXXXVII.—*continued.*

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lacomd.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
4— cont.	12 noon, June 27th, 1896	—	600	V. ft. acid	0·18			Traces.			
	12 " " 28th "	—	600	? neutral	0·12			Traces.			
	January 27th to February 3rd peat given a rest.	—	700	V. ft. acid	0·94	0·0	0·06	0·05	0·1	0·08	
	12 noon, February 4th, 1896	—	500	? neutral	0·12			Traces.			
	12 " " 5th "	—	600	V. ft. acid	0·18			? traces.			
	February 6th to 11th peat given a rest.	—	500	Neutral	0·12	0·0	0·0	0·0	0·0	0·00	
	12 noon, February 12th, 1896	—	500	? Neutral	0·13			? traces.			
	12 " " 13th "	—	500	Acid	0·24	0·05	0·1	0·1	0·1	0·1	0·09
	February 13th to 18th peat given a rest.	—	500	? Neutral	0·18			Trace			
	12 noon, February 20th, 1896	—	500	? Neutral	0·18						
5	12 " " 21st "	—	250	Acid	0·24						
	February 21st to 27th peat given a rest.	—	250	? Neutral	0·18						
5	12 noon, February 28th, 1896	—	250	—	—						
	Experiment started 9 a.m. July 2nd, 1896. Conditions same as in Experiment 1.	250 grms. Oldham peat.	—	—	—						On February 8th, 1896, Experiment 4 was abandoned. The sample of peat was obtained from the Borden Works (Oldham Corporation Waterworks), which in 1896 were in course of construction.



It will be noted that these experiments, being of a more exhaustive and detailed character, go farther to confirm the results already dealt with in Table CXXXV.

In Experiment 1, 300 grammes of Bradford peat sufficed, under the conditions of the experiment, to render acid and plumbo-solvent in character 100,970 c.c.\* of previously neutral and non-plumbo-solvent distilled water (1 part of peat to 336 parts of water). Whenever the acidity of the filtrate showed signs of being exhausted, resting the peat usually led to a subsequent re-development of acidity.

Similarly, in Experiment 2, 300 grammes of Huddersfield peat conferred acid and plumbo-solvent properties on 53,750 c.c. of distilled water (1 part of peat to 179 parts of water).

In Experiment 3, 150 grammes of Settle peat rendered 44,950 c.c. of distilled water acid and plumbo-solvent in character (1 part of peat to 299 parts of water).

In Experiment 4, 150 grammes of Mossley peat conferred acid and plumbo-solvent properties on 30,850 c.c. of distilled water (1 part of peat to 206 parts of water).

In Experiment 5, 250 grammes of Oldham peat rendered acid and plumbo-solvent in character 13,900 c.c. of distilled water (1 part of peat to 55 parts of water). The sample of Oldham peat was taken at a depth of 8 feet from the surface; this circumstance may possibly account for the fact that the acidity and solvent action on lead of the filtrate from this peat sample were not so well marked as in the other experiments.

The experiments, as a whole, show the remarkable power of a relatively small bulk of peat to render acid and plumbo-solvent in character a relatively large bulk of neutral water. It is obvious that, on the average, less than 1 part of peat is capable of conferring dangerous properties on more than 200 parts of water, provided the filtration process is intermittent in character. The increase, after the peat had been allowed to rest for some time, in the acidity and plumbo-solvent ability of the filtrate, is an instructive feature of the experiments. Some such state of things prevails on moorland gathering grounds. Here the rain falling on the peat saturates it and escapes slowly by lateral filtration.

Between each successive rainfall (corresponding to the intermittent character of my experiments, and the periods of rest occasionally given) acid substances are doubtless manufactured and stored in the peat. These are "washed out" during storm time and so contaminate the water supply. It has been observed repeatedly on moorland gathering grounds that the "first washings" of the peat are apt to be excessively acid and to possess a vigorous solvent action on lead.

An important and prolonged series of experiments will next be considered, in which are shown the results, as regards acidity and plumbo-solvency, of passing water slowly, but continuously, through peat saturated with water.

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\* In this, as in the succeeding experiments, the total bulk of filtrate is given. On rare occasions a particular filtrate was practically neutral and free from plumbo-solvency; but as the earlier filtrates from the same sample of peat were decidedly acid and acted vigorously on lead, these filtrates are included in the computation; for, if all the filtrates had been mixed together, the mixture would most certainly be acid and plumbo-solvent in character.

TABLE OXXXVIII.

Showing the Results, as regards Acidity and PLUMBO-SOLVENCY, of passing WATER slowly but continuously through PEAT saturated with Water. (See Plate VI., Fig. 9.)

The apparatus used in these experiments consisted of a glazed earthenware cylinder (about 24" x 6"), tapered at its lower end to admit of the introduction of a rubber bung. A perforated earthenware disc covered with muslin rested at the lower end of the cylinder, and on this the peat used in the experiments was placed. A piece of bent-glass tubing filled a hole in the bung, and was connected with another piece of glass tubing, which reached nearly to the top of the cylinder, and through which at the start of the experiment water was delivered so as to fill the apparatus from below upwards. A bent-glass tube was connected subsequently with this, and served as an overflow pipe when water was allowed to drop continuously into the cylinder from above.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1	13 noon, July 14th, 1895. 1,000 grms. Settle peat placed on perforated earthenware disc. 7,700 c.c. distilled water (previously boiled and free from plumbo-solvent ability) introduced into cylinder from below upwards.	grms. 1,000	c.c. 7,700	c.c. —	—	—	—	—	—	—	—	The sample of peat was obtained from moorland near Settle. The water, after passing through the peat, usually contained traces of iron.
8	p.m., July 14th, 1895. Distilled water allowed to drop into cylinder from above, and collected—after passing through the contents of the cylinder—from overflow pipe, and periodically examined for acidity and plumbo-solvency.	—	1,275	1,275	Acid	0.46	0.1	0.2	0.2	0.3	0.4	0.24
11	p.m., July 14th, 1895	—	860	860	"	0.73	0.2	0.6	0.6	0.6	0.8	0.55
3.40	" 15th, "	—	—	—	—	—	—	—	—	—	—	—

TABLE CXXXVIII. — continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lacomoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		
							Average.						
1— contd.	12.30 p.m., July 16th, 1898	—	grms.	c.c.	c.c.	Acid	1.08	0.4	1.4	1.6	2.0	1.40	
3	16th "	—	—	1,700	1,940	"	1.20	1.0	1.6	2.0	2.0	1.73	
3	17th "	—	—	1,480	1,480	"	0.80	0.8	1.6	1.6	1.6	1.44	
3	18th "	—	—	1,280	1,280	"	1.30	0.4	1.0	1.4	1.6	1.12	
3	19th "	—	—	1,500	1,500	"	1.30	0.8	1.2	1.2	1.4	1.20	
3	20th "	—	—	1,625	1,625	"	1.90	1.2	2.0	2.4	2.4	2.08	
3	21st "	—	—	1,420	1,420	"	1.80	1.2	2.0	2.0	2.0	1.84	
3	22nd "	—	—	1,640	1,640	"	2.00	1.2	2.0	2.4	2.4	2.08	
3	23rd "	—	—	1,350	1,350	"	2.10	1.2	2.0	2.0	2.0	1.84	
3	24th "	—	—	1,250	1,250	"	1.40	1.0	1.6	1.6	1.6	1.46	
3	25th "	—	—	1,300	1,300	"	1.30	0.2	0.8	0.8	0.8	0.68	
3	26th "	—	—	850	850	"	1.00	0.2	0.3	0.5	0.5	0.40	
3	27th "	—	—	950	950	"	1.20	0.6	0.8	0.8	0.8	0.80	
3	28th "	—	—	700	700	"	1.10	0.4	0.8	0.8	0.8	0.72	
13 noon, July	29th "	—	—	2,000	2,000	"	1.70	1.2	1.4	1.6	1.4	1.44	
13 "	30th "	—	—	1,050	1,050	"	1.00	0.1	0.4	0.4	0.4	0.38	



TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lactoid.	Acidity in Terms of c.c. 10 $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1— cc. of	12 noon, August 23rd, 1895	grms.	c.c. 2,000	c.c. 2,000	Acid	0.54	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 24th "	—	2,000	2,000	"	0.54	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 25th "	—	2,000	2,000	"	0.54	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 26th "	—	1,850	1,850	"	0.54	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 27th "	—	2,050	2,050	"	0.42	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 28th "	—	2,200	2,200	"	0.48	0.1	0.1	0.1	0.2	0.2	0.14
12 "	" " 29th "	—	2,100	2,100	"	0.42	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 30th "	—	1,850	1,850	"	0.42	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 31st "	—	2,300	2,300	"	0.48	0.0	0.1	0.1	0.1	0.1	0.08
12 "	September 1st, 1895	—	2,350	2,350	"	0.42	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 2nd "	—	1,550	1,550	"	0.30	0.0	0.1	0.1	0.1	0.0	0.08
12 "	" " 3rd "	—	1,900	1,900	"	0.48	0.0	0.1	0.1	0.1	0.1	0.08
12 "	" " 4th "	—	800	800	"	0.42	0.0	0.0	0.1	0.1	0.1	0.08
12 "	" " 5th "	—	950	950	"	0.42	0.0	0.0	0.1	0.1	0.1	0.08
12 "	" " 6th "	—	900	900	"	0.42	0.1	0.1	0.1	0.1	0.1	0.10
12 "	" " 7th "	—	1,250	1,250	"	0.54	0.1	0.0	0.0	0.1	0.1	0.08

18	"	"	8th	"	"	—	1,400	1,400	"	0.60	0.2	0.1	0.2	0.3	0.3	0.22
18	"	"	9th	"	"	—	1,250	1,250	"	0.48	0.0	0.1	0.1	0.1	0.2	0.10
18	"	"	10th	"	"	—	1,250	1,250	"	0.60	0.0	0.1	0.1	0.1	0.1	0.08
12	"	"	11th	"	"	—	1,150	1,150	"	0.54	0.1	0.1	0.2	0.2	0.2	0.16
12	"	"	12th	"	"	—	1,000	1,000	"	0.42	0.0	0.0	0.1	0.1	0.1	0.08
12	"	"	13th	"	"	—	950	950	"	0.48	0.1	0.1	0.1	0.1	0.1	0.10
12	"	"	14th	"	"	—	950	950	"	0.42	0.0	0.0	0.0	0.1	0.1	0.04
12	"	"	15th	"	"	—	1,050	1,050	"	0.54	0.0	0.1	0.1	0.1	0.1	0.08
12	"	"	16th	"	"	—	900	900	"	0.54	0.2	0.4	0.4	0.4	0.5	0.38
12	"	"	17th	"	"	—	850	850	"	0.42	0.0	0.1	0.2	0.2	0.3	0.18
12	"	"	18th	"	"	—	950	950	"	0.48	0.1	0.1	0.1	0.2	0.2	0.14
12	"	"	19th	"	"	—	950	950	"	0.48	0.1	0.1	0.1	0.1	0.1	0.10
12	"	"	20th	"	"	—	1,000	1,000	"	0.48	0.1	0.0	0.1	0.1	0.1	0.08
12	"	"	21st	"	"	—	1,100	1,100	"	0.60	0.2	0.4	0.5	0.6	0.6	0.46
12	"	"	22nd	"	"	—	1,150	1,150	"	0.48	0.1	0.4	0.4	0.5	0.4	0.36
12	"	"	23rd	"	"	—	1,300	1,300	"	0.48	0.1	0.4	0.4	0.5	0.4	0.36
12	"	"	24th	"	"	—	850	850	"	0.36	0.1	0.1	0.2	0.2	0.2	0.16
12	"	"	25th	"	"	—	1,100	1,100	"	0.42	0.0	0.1	0.1	0.1	0.1	0.08
12	"	"	26th	"	"	—	1,100	1,100	"	0.48	0.1	0.1	0.1	0.2	0.2	0.14
12	"	"	27th	"	"	—	1,150	1,150	"	0.54	0.1	0.1	0.2	0.3	0.4	0.22
12	"	"	28th	"	"	—	1,000	1,000	"	0.54	0.1	0.1	0.2	0.2	0.1	0.14
12	"	"	29th	"	"	—	1,350	1,350	"	0.48	0.1	0.1	0.2	0.2	0.2	0.16
12	"	"	30th	"	"	—	1,000	1,000	"	0.48	0.1	0.1	0.1	0.1	0.2	0.12



TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000.) The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
1— cont	13 noon, October 1st, 1895	—	c.c. 1,350	c.c. 1,350	Acid	0.72	0.3	0.5	0.7	0.8	0.8	0.63
	12 " " 2nd "	—	1,000	1,000	"	0.36	0.0	0.1	0.1	0.1	0.1	0.08
	13 " " 3rd "	—	1,200	1,200	"	0.54	0.0	0.1	0.2	0.2	0.3	0.16
	13 " " 4th "	—	1,000	1,000	"	0.36	0.0	0.1	0.1	0.1	0.1	0.09
	13 " " 5th "	—	900	900	"	0.48	0.0	0.1	0.1	0.1	0.1	0.08
	13 " " 6th "	—	1,100	1,100	"	0.48	0.0	0.1	0.1	0.1	0.1	0.08
	13 " " 7th "	—	1,200	1,200	"	0.36	0.0	0.1	0.1	0.1	0.1	0.08
	13 " " 8th "	—	1,200	1,200	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
	13 " " 8th "	1,000	8,200	—	—	—	—	—	—	—	—	—
	3 p.m., July 20th, 1895. 1,000 grms. Settle peat placed on perforated earthenware disc. 8,200 c.c. of water from the River Ribble (neutral and free from plumbo-solvent ability) introduced into cylinder from below upwards.								Traces.			The sample of peat was obtained from moorland near Settle. In Experiment 2, Ribble water was used instead of distilled water. The water after passing through the peat usually contained traces of iron.
2	11.45 p.m., July 20th, 1895. Ribble water allowed to drop into cylinder from above and—after passing through the contents of cylinder—collected from overflow pipe, and periodically tested for acidity and plumbo-solvent ability.											



TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.
							1st. 50 c.c.	2nd. 50 c.c.	3rd. 50 c.c.	4th. 50 c.c.	5th. 50 c.c.	
2— cont.	12 noon, August 13th, 1898	—	c.c. 600	c.c. 600	Acid	1.70	0.2	0.4	0.6	0.6	0.6	0.46
13	" " 14th "	—	1,200	1,200	"	2.00	0.2	0.6	1.0	0.8	1.0	0.73
13	" " 15th "	—	1,680	1,680	"	2.00	0.2	1.0	1.0	1.0	1.0	0.84
13	" " 16th "	—	1,380	1,380	"	1.90	0.4	1.0	1.0	1.2	1.2	0.06
13	" " 17th "	—	1,000	1,000	"	1.30	0.2	0.6	0.6	0.6	0.6	0.53
13	" " 18th "	—	325	325	"	0.84	0.05	0.2	0.4	0.4	0.6	0.33
13	" " 19th "	—	1,730	1,730	"	2.00	0.4	1.2	1.6	1.6	1.2	1.30
13	" " 20th "	—	1,200	1,200	"	2.30	0.4	1.2	1.2	1.2	1.0	1.00
13	" " 21st "	—	2,550	2,550	"	2.40	0.6	1.6	1.6	1.6	1.6	1.40
13	" " 22nd "	—	2,100	2,100	"	1.80	0.4	1.0	1.0	0.8	1.0	0.81
13	" " 23rd "	—	1,500	1,500	"	1.30	0.2	0.4	0.4	0.4	0.4	0.36
13	" " 24th "	—	1,300	1,300	"	2.40	0.6	1.2	1.6	1.6	1.6	1.32
13	" " 25th "	—	1,500	1,500	"	2.30	0.6	1.2	1.6	1.6	1.6	1.32
13	" " 26th "	—	1,550	1,550	"	2.40	0.6	1.0	1.4	1.4	1.6	1.20
13	" " 27th "	—	1,060	1,060	"	1.40	0.1	0.4	0.4	0.4	0.4	0.34
13	" " 28th "	—	1,150	1,150	"	1.90	0.2	0.6	0.6	0.6	0.8	0.56



TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Læmold.	Addity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100 000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
		grms.	c.c.	c.c.			1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
2—cont	13 noon, September 31st, 1895.	—	1,500	1,500	Acid	1.60	0.2	0.4	0.4	0.4	0.4	0.36	
13	" " 28nd "	—	2,100	2,100	"	1.40	0.2	0.2	0.2	0.2	0.4	0.24	
13	" " 23rd "	—	1,550	1,550	"	0.98	0.2	0.2	0.2	0.2	0.2	0.20	
13	" " 24th "	—	2,150	2,150	"	1.08	0.2	0.2	0.2	0.2	0.2	0.20	
13	" " 25th "	—	1,800	1,800	"	1.20	0.0	0.2	0.2	0.2	0.2	0.16	
13	" " 26th "	—	1,350	1,350	"	0.98	0.0	0.1	0.1	0.2	0.2	0.12	
12	" " 27th "	—	1,400	1,400	"	1.20	0.1	0.1	0.2	0.2	0.2	0.16	
13	" " 28th "	—	1,800	1,800	"	1.60	0.0	0.2	0.2	0.3	0.4	0.28	
13	" " 29th "	—	1,350	1,350	"	0.98	0.0	0.1	0.2	0.1	0.1	0.10	
13	" " 30th "	—	1,600	1,600	"	1.60	0.2	0.4	0.4	0.3	0.4	0.34	
13	" " 1st October	—	2,100	2,100	"	1.30	0.1	0.1	0.2	0.2	0.3	0.18	
13	" " 2nd "	—	2,100	2,100	"	1.20	0.0	0.1	0.1	3.3	0.3	0.16	
13	" " 3rd "	—	2,400	2,400	"	1.30	0.1	0.1	0.1	0.2	0.2	0.14	
13	" " 4th "	—	1,450	1,450	"	0.98	0.1	0.2	0.1	0.2	0.1	0.14	
13	" " 5th "	—	1,500	1,500	"	0.78	0.0	0.0	0.0	0.1	0.1	0.04	
13	" " 6th "	—	2,500	2,500	"	1.30	0.0	0.1	0.1	0.1	0.2	0.10	

18	"	"	7th	-	-	1,400	1,400	"	0.84	0.1	0.1	0.1	0.1	0.1	0.1	0.10
18	"	"	8th	-	-	1,700	1,700	"	0.80	0.05	0.05	0.1	0.1	0.1	0.1	0.08
3	7 a.m.	August 5th, 1895.	1,000 grammes Huddersfield peat placed on earthenware disc. 7,500 c.c. distilled water (previously boiled and free from plumbo-solvent ability) introduced into cylinder from below upwards.	1,000	7,800	-	-	-	-	-	-	-	-	-	-	-
9	a.m.	August 7th.	Distilled water allowed to drop into cylinder from above and collected—after passing through the contents of the cylinder—from overflow pipe, and periodically examined for acidity and plumbo-solvent ability.	-	-	-	-	-	-	-	-	-	-	-	-	-
9	a.m.	August 8th, 1895.	-	-	1,900	1,600	Acid	0.73	0.4	0.8	0.8	1.2	1.2	1.2	1.2	0.88
9	"	"	9th	-	750	750	"	0.66	0.1	0.8	0.8	0.8	0.8	0.8	0.8	0.86
9	"	"	10th	-	1,250	1,250	"	0.72	0.6	1.0	1.2	1.0	1.0	1.0	1.0	0.86
9	"	"	11th	-	1,250	1,250	"	0.66	0.4	1.0	1.0	1.0	1.0	1.0	1.0	0.84
9	"	"	12th	-	1,350	1,350	"	0.60	0.4	0.8	0.8	0.8	0.8	1.0	1.0	0.76
9	"	"	13th	-	1,550	1,550	"	0.54	0.4	0.8	0.8	0.8	0.8	0.8	0.8	0.72
9	"	"	14th	-	900	900	"	0.42	0.2	0.4	0.6	0.8	0.8	0.8	0.8	0.56
9	"	"	15th	-	1,180	1,180	"	0.46	0.2	0.6	0.6	0.8	0.8	0.8	0.8	0.60
9	"	"	16th	-	1,150	1,150	"	0.46	0.1	0.4	0.4	0.6	0.6	0.6	0.6	0.42
9	"	"	17th	-	1,200	1,200	"	0.46	0.2	0.6	0.6	0.8	0.8	0.8	0.8	0.60
9	"	"	18th	-	750	750	"	0.42	0.2	0.4	0.6	0.6	0.6	0.6	0.6	0.46
9	"	"	19th	-	650	650	"	0.42	0.05	0.2	0.4	0.4	0.4	0.4	0.4	0.29
9	"	"	20th	-	1,750	1,750	"	0.54	0.2	0.4	0.6	0.6	0.6	0.6	0.6	0.46

The sample of peat was obtained from the moorland gathering-ground of the Huddersfield water supply. The water after passing through the peat usually contained traces of iron.

TABLE CXXXVIII.--continued

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Leadmold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
3— cont.	9 a.m., August 21st, 1896	—	c.c. 1,900	c.c. 1,900	Acid	0.43	0.2	0.6	0.8	0.6	0.6	0.56
	9 " " 22nd "	—	1,850	1,850	"	0.36	0.2	0.6	0.6	0.6	0.6	0.53
	9 " " 23rd "	—	900	900	"	0.30	0.2	0.2	0.2	0.2	0.2	0.22
	9 " " 24th "	—	1,600	1,600	"	0.30	0.2	0.2	0.2	0.2	0.2	0.26
	9 " " 25th "	—	1,550	1,550	"	0.36	0.1	0.1	0.1	0.1	0.2	0.13
	9 " " 26th "	—	1,300	1,300	"	0.36	0.0	0.1	0.1	0.1	0.2	0.10
	9 " " 27th "	—	1,550	1,550	"	0.36	0.0	0.1	0.3	0.4	0.3	0.23
	9 " " 28th "	—	1,350	1,350	"	0.30	0.0	0.2	0.3	0.3	0.3	0.22
	9 " " 29th "	—	1,400	1,400	"	0.30	0.0	0.1	0.3	0.2	0.2	0.14
	9 " " 30th "	—	1,150	1,150	"	0.30	0.1	0.2	0.2	0.2	0.2	0.18
	9 " " 31st "	—	1,350	1,350	"	0.24	0.1	0.0	0.0	0.1	0.1	0.06
	9 " September 1st, 1896	—	1,750	1,750	"	0.50	0.0	.1	0.1	0.1	0.2	0.10
	9 " " 2nd "	—	2,050	2,050	"	0.24	0.1	0.1	0.1	0.1	0.1	0.10
	9 " " 3rd "	—	1,000	1,000	"	0.15	0.0	0.0	0.1	0.1	0.1	0.06
	9 " " 4th "	—	950	950	"	0.18	0.0	0.1	0.1	0.1	0.2	0.10
	9 " " 5th "	—	950	950	"	0.30	0.0	0.2	0.1	0.1	0.1	0.10

9 "	"	6th "	-	1,600	1,600	"	0.30	0.0	0.0	0.1	0.1	0.1	0.08
9 "	"	7th "	-	1,000	1,000	"	0.24	0.0	0.0	0.0	0.1	0.1	0.04
9 "	"	8th "	-	1,400	1,400	"	0.30	0.0	0.0	0.1	0.1	0.1	0.08
9 "	"	9th "	-	1,600	1,600	"	0.24	0.0	0.0	0.0	0.1	0.1	0.04
9 "	"	10th "	-	1,700	1,700	"	0.24	0.0	0.0	0.1	0.0	0.1	0.04
9 "	"	11th "	-	1,050	1,050	"	0.24	0.0	0.1	0.1	0.2	0.2	0.12
9 "	"	12th "	-	1,250	1,250	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
9 "	"	13th "	-	1,350	1,350	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
9 "	"	14th "	-	1,050	1,050	"	0.24	0.0	0.1	0.1	0.1	0.2	0.10
9 "	"	15th "	-	1,450	1,450	"	0.20	0.1	0.1	0.2	0.2	0.2	0.16
9 "	"	16th "	-	1,400	1,400	"	0.18	0.0	0.1	0.1	0.1	0.2	0.10
9 "	"	17th "	-	1,350	1,350	"	0.24	0.1	0.1	0.1	0.1	0.1	0.10
9 "	"	18th "	-	1,000	1,000	"	0.30	0.1	0.1	0.1	0.1	0.1	0.08
9 "	"	19th "	-	1,350	1,350	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08
9 "	"	20th "	-	1,500	1,500	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08
9 "	"	21st "	-	1,200	1,200	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08
9 "	"	22nd "	-	1,100	1,100	"	0.18	0.0	0.1	0.1	0.1	0.1	0.08
9 "	"	23rd "	-	1,250	1,250	"	0.20	0.1	0.1	0.1	0.1	0.1	0.10
9 "	"	24th "	-	1,450	1,450	"	0.24	0.0	0.1	0.1	0.1	0.1	0.08
9 "	"	25th "	-	1,250	1,250	"	0.30	0.0	0.2	0.2	0.2	0.2	0.16
9 "	"	26th "	-	650	650	"	0.36	0.0	0.1	0.1	0.2	0.2	0.12
9 "	"	27th "	-	1,100	1,100	"	0.24	0.1	0.2	0.1	0.2	0.1	0.14
9 "	"	28th "	-	1,150	1,150	"	0.36	0.0	0.2	0.2	0.2	0.2	0.18



TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Loomoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{N}_2\text{S}_2\text{O}_8$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
3— cont	9 a.m., September 29th 1895	—	c.c. 1,150	c.c. 1,150	Acid	0.24	0.1	0.1	0.1	0.2	0.14	The sample of peat was obtained from the moorland gathering ground of the Halifax water supply. The water after passing through the peat contained at first slight traces of iron. In this experiment only 100 grms. of peat were used, instead of 1,000 grms. as in the previous experiments.
	9 " " 30th "	—	1,350	1,350	"	0.30	0.0	0.1	0.2	0.2	0.14	
	9 " October 1st "	—	700	700	"	0.18	0.0	0.1	0.1	0.1	0.2	
	9 " " 2nd "	—	900	900	"	0.24	0.0	0.1	0.1	0.1	0.08	
	9 " " 3rd "	—	1,350	1,350	"	0.20	0.0	0.1	0.1	0.2	0.1	
	9 " " 4th "	—	900	900	"	0.30	0.1	0.2	0.1	0.1	0.2	
	9 " " 5th "	—	950	950	"	0.20	0.0	0.1	0.1	0.1	0.08	
	9 " " 6th "	—	1,150	1,150	"	0.20	0.0	0.1	0.1	0.1	0.08	
	9 " " 7th "	—	900	900	"	0.20	0.0	0.0	0.0	0.1	0.04	
	9 " " 8th "	—	1,350	1,350	"	0.20	0.0	0.0	0.0	0.1	0.1	
	19 noon, Sept. 18th, 1895. 100 grms. Halifax peat placed on perforated earthenware disc at foot of cylinder. 9,000 c.c. distilled water (previously boiled and free from plumbo-solvent ability) introduced into cylinder from below upwards.	100	9,000	—	—	—	—	—	—	—	—	
	10 p.m., Sept. 18th, 1895. Distilled water allowed to drop into cylinder from above and collected—after passing through the contents of the cylinder—from overflow pipe and periodically examined for acidity and plumbo-solvent ability.											

13 noon, September 14th, 1895	-	-	850	850	Acid	0.24	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 16th "	-	-	700	700	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 16th "	-	-	1,000	1,000	"	0.43	0.1	0.1	0.2	0.2	0.2	0.16
13 " " 17th "	-	-	800	800	"	0.36	0.1	0.1	0.1	0.2	0.2	0.14
13 " " 18th "	-	-	1,000	1,000	"	0.43	0.1	0.1	0.1	0.2	0.2	0.14
13 " " 19th "	-	-	600	600	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 20th "	-	-	1,100	1,100	"	0.30	0.0	0.1	0.1	0.1	0.2	0.14
13 " " 21st "	-	-	1,300	1,300	"	0.36	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 22nd "	-	-	600	600	Faintly acid.	0.24	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 23rd "	-	-	1,550	1,550	Acid.	0.36	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 24th "	-	-	700	700	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 25th "	-	-	1,300	1,300	"	0.36	0.1	0.1	0.1	0.1	0.1	0.10
13 " " 26th "	-	-	900	900	"	0.42	0.1	0.1	0.1	0.1	0.2	0.12
13 " " 27th "	-	-	800	800	"	0.36	0.1	0.2	0.2	0.2	0.2	0.16
13 " " 28th "	-	-	1,300	1,300	"	0.42	0.1	0.2	0.2	0.2	0.1	0.16
13 " " 29th "	-	-	1,800	1,800	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 30th "	-	-	2,150	2,150	"	0.24	0.0	0.1	0.1	0.1	0.1	0.08
13 " " October 1st, 1895	-	-	1,000	1,000	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 2nd "	-	-	2,400	2,400	"	0.24	0.1	0.1	0.1	0.1	0.1	0.10
13 " " 3rd "	-	-	900	900	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 4th "	-	-	1,000	1,000	"	0.18	0.0	0.1	0.1	0.1	0.1	0.08
13 " " 5th "	-	-	1,500	1,500	"	0.24	0.1	0.1	0.1	0.1	0.1	0.10
13 " " 6th "	-	-	1,700	1,700	"	0.24	0.0	0.0	0.0	0.1	0.1	0.04

TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder, grms.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Læmdd.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
4	12 noon, October 7th, 1895	grms. —	c.c. 1,500	c.c. 1,500	Faintly acid.	0.18	0.1	0.0	0.1	0.1	0.1	0.08
	12 " " 8th "	—	1,300	1,300	"	0.18	0.05	0.1	0.1	0.1	0.1	0.08
	12 " " 9th "	—	2,250	2,350	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08
	12 " " 10th "	—	1,700	1,700	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08
	12 " " 11th "	—	1,050	1,050	"	0.20	0.0	0.1	0.1	0.1	0.1	0.08
	12 " " 12th "	—	1,300	1,300	"	0.18	Traces.					0.08
	12 " " 13th "	—	1,150	1,150	"	0.18	0.0	0.1	0.1	0.1	0.1	0.08
	12 " " 14th "	—	700	700	"	0.18	Traces.					0.08
	12 " " 15th "	—	1,500	1,500	"	0.18	Traces.					0.08
	12 noon, October 8th, 1895.—500 grms. Halifax peat placed on perforated earthenware disc at foot of cylinder. 7,700 c.c. rain water (neutral and free from plumbo-solvent ability) introduced from below upwards.	500	7,700	—	—	—	—	—	—	—	—	The sample of peat was obtained from the moorland gathering ground of Halifax water supply.
5	3 p.m., October 8th, 1895.—Rain water allowed to drop into cylinder from above, and collected—after passing through contents of cylinder—from overflow pipe and periodically tested for acidity and plumbo-solvent ability.				—	—	—	—	—	—	—	The water after passing through the peat usually contained traces of iron.

9 a.m., October 9th, 1895	500	500	Faintly acid.	0.30	0.2	0.8	1.0	1.0	1.0	1.0	1.0
9 "	900	900	"	0.78	0.4	1.2	1.6	1.6	1.6	1.6	1.08
9 "	1,300	1,300	"	0.72	0.8	1.2	1.2	1.2	1.2	1.2	1.13
9 "	750	750	"	0.66	0.4	1.2	1.2	1.2	1.2	1.2	1.02
9 "	850	850	"	0.60	0.4	0.4	0.4	0.8	0.8	0.8	0.53
9 "	600	600	"	0.54	0.8	1.2	1.2	1.6	1.6	1.6	1.28
9 "	900	900	"	0.72	0.8	0.8	1.2	1.2	1.6	1.6	1.28
9 "	750	750	"	0.72	0.8	1.4	1.4	1.4	1.4	1.4	1.24
9 "	1,050	1,050	"	0.60	0.6	1.2	1.2	1.2	1.6	1.6	1.24
9 "	1,350	1,350	"	0.54	0.8	1.0	1.2	1.4	1.4	1.4	1.12
9 "	1,550	1,550	"	0.48	0.6	0.8	1.0	1.0	1.0	1.0	0.88
9 "	1,000	1,000	"	0.48	0.6	1.2	1.2	1.2	1.4	1.4	1.12
9 "	700	700	"	0.48	0.4	0.8	1.0	1.2	1.4	1.4	0.96
9 "	800	800	"	0.48	0.6	1.2	1.2	1.4	1.4	1.4	1.16
9 "	800	800	"	0.54	0.6	1.0	1.0	1.2	1.2	1.2	1.00
9 "	500	500	"	0.42	0.6	1.2	1.2	1.2	1.2	1.2	1.08
9 "	1,050	1,050	"	0.48	0.4	1.0	1.2	1.2	1.2	1.2	1.00
9 "	950	950	"	0.48	0.6	1.2	1.2	1.4	1.4	1.4	1.16
9 "	2,000	2,000	"	0.42	0.6	1.2	1.2	1.2	1.4	1.4	1.12
9 "	800	800	"	0.48	0.6	1.2	1.2	1.2	1.4	1.4	1.12
9 "	1,300	1,300	"	0.54	0.6	1.2	1.2	1.6	1.6	1.6	1.24
9 "	800	800	"	0.60	0.6	1.4	1.6	1.8	1.8	1.8	1.44
9 "	900	900	"	1.42	0.4	0.8	0.8	0.8	1.0	1.0	0.76

TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lacomoid.	Acidity in Terms of c.c. $\frac{1}{2}$ N <sub>2</sub> CO <sub>3</sub> needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
5—conf	9 a.m., November 1st, 1895	—	850	850	Acid	0.42	0.4	0.8	0.8	0.8	1.0	0.76
9 "	" 2nd "	—	800	800	"	0.30	0.2	0.4	0.4	0.4	0.5	0.38
9 "	" 3rd "	—	500	500	"	0.42	0.4	0.8	0.8	1.0	1.2	0.84
9 "	" 4th "	—	500	500	"	0.54	0.2	1.0	1.0	1.0	1.2	0.88
9 "	" 5th "	—	600	600	"	0.42	0.4	0.8	0.8	1.2	1.2	0.88
9 "	" 6th "	—	950	950	"	0.54	0.4	0.8	1.2	1.2	1.2	0.96
9 "	" 7th "	—	1,750	1,750	"	0.42	0.4	0.8	1.0	1.0	1.0	0.84
9 "	" 8th "	—	750	750	"	0.42	0.4	0.8	1.2	1.2	1.2	0.96
9 "	" 9th "	—	700	700	"	0.42	0.2	0.6	0.6	0.6	0.6	0.52
9 "	" 10th "	—	500	500	"	0.36	0.2	6.2	0.4	0.4	0.4	0.32
9 "	" 11th "	—	550	550	"	0.36	0.2	0.2	0.2	0.4	0.4	0.28
9 "	" 12th "	—	750	750	"	0.42	0.4	0.8	1.0	1.0	1.2	0.88
9 "	" 13th "	—	750	750	"	0.36	0.2	0.2	0.4	0.4	0.6	0.36
9 "	" 14th "	—	750	750	"	0.42	0.4	0.8	1.0	1.0	1.2	0.88
9 "	" 15th "	—	750	750	"	0.42	0.2	0.4	0.6	0.6	0.6	0.46
9 "	" 16th "	—	650	650	"	0.30	0.1	0.1	0.1	0.2	0.2	0.14

9 "	17th "	1,300	1,300	"	0.42	0.4	0.8	0.8	1.0	1.0	0.80
9 "	18th "	600	600	"	0.42	0.3	0.8	0.6	0.6	0.8	0.42
9 "	19th "	650	650	"	0.42	0.4	0.8	0.8	0.8	0.8	0.72
9 "	20th "	1,300	1,300	"	0.42	0.4	0.8	1.2	1.2	1.2	0.92
9 "	21st "	750	750	"	0.42	0.2	0.6	0.8	0.8	0.8	0.64
9 "	22nd "	1,000	1,000	"	0.42	0.4	0.6	0.8	0.8	0.8	0.68
9 "	23rd "	1,300	1,300	"	0.42	0.4	0.6	0.6	0.8	1.0	0.68
9 "	24th "	1,000	1,000	"	0.42	0.4	0.8	0.8	0.8	1.0	0.76
9 "	25th "	700	700	"	0.36	0.2	0.4	0.6	0.6	0.6	0.42
9 "	26th "	750	750	"	0.42	0.4	0.8	1.0	1.0	1.0	0.84
9 "	27th "	950	950	"	0.42	0.4	0.8	1.0	1.0	1.0	0.84
9 "	28th "	800	800	"	0.42	0.4	0.6	0.8	0.8	1.0	0.72
9 "	29th "	1,000	1,000	"	0.42	0.4	0.8	0.8	1.0	1.0	0.90
9 "	30th "	650	650	"	0.42	0.2	0.4	0.6	0.6	0.6	0.42
9 "	December 1st "	550	550	"	0.42	0.1	0.2	0.2	0.2	0.4	0.32
9 "	2nd "	550	550	"	0.42	0.2	0.4	0.6	0.6	0.8	0.72
9 "	3rd "	700	700	"	0.42	0.2	0.4	0.4	0.4	0.6	0.40
9 "	4th "	550	550	"	0.42	0.2	0.4	0.6	0.6	0.6	0.42
9 "	5th "	1,000	1,000	"	0.36	0.2	0.4	0.4	0.6	0.6	0.44
9 "	6th "	700	700	"	0.36	0.2	0.4	0.6	0.8	0.8	0.56
9 "	7th "	600	600	"	0.36	0.2	0.4	0.6	0.8	0.8	0.56
9 "	8th "	600	600	"	0.42	0.4	0.8	0.8	1.0	1.0	0.80
9 "	9th "	1,300	1,300	"	0.42	0.4	0.6	1.0	1.0	1.0	0.80

TABLE CXXXVIII.—*continued.*

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					Remarks.	
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
5— <i>cont.</i>	9 a.m., December 10th, 1895	—	grms.	c.c.	c.c.	600	600	600	600	600	600	600	
9 "	" 11th "	—	—	700	700	700	0.6	1.0	1.0	1.0	1.2	1.2	0.86
9 "	" 12th "	—	—	500	500	500	0.2	0.4	0.4	0.6	0.6	0.6	0.44
9 "	" 13th "	—	—	500	500	500	0.4	0.6	0.8	0.8	1.0	1.0	0.72
9 "	" 14th "	—	—	750	750	750	0.2	0.2	0.2	0.2	0.4	0.4	0.34
9 "	" 15th "	—	—	600	600	600	0.4	0.6	0.8	0.8	1.0	1.0	0.72
9 "	" 16th "	—	—	500	500	500	0.2	0.4	0.4	0.6	0.6	0.6	0.40
9 "	" 17th "	—	—	500	500	500	0.1	0.2	0.3	0.3	0.3	0.3	0.24
9 "	" 18th "	—	—	700	700	700	0.2	0.4	0.4	0.4	0.4	0.4	0.36
9 "	" 19th "	—	—	500	500	500	0.2	0.6	0.8	0.8	0.8	0.8	0.64
9 "	" 20th "	—	—	500	500	500	0.2	0.4	0.6	0.8	0.8	0.8	0.56
9 "	" 21st "	—	—	500	500	500	0.2	0.4	0.8	1.2	1.2	1.2	0.76
9 "	" 22nd "	—	—	500	500	500	0.2	0.2	0.2	0.2	0.4	0.4	0.24
9 "	" 23rd "	—	—	1,100	1,100	1,100	0.1	0.1	0.1	0.1	0.1	0.1	0.10
9 "	" 24th "	—	—	1,200	1,200	1,200	0.4	0.8	0.8	0.8	1.2	1.2	0.80
9 "	" 25th "	—	—	800	800	800	0.2	0.2	0.2	0.3	0.3	0.3	0.24
9 "	" 26th "	—	—	—	—	—	0.1	0.1	0.2	0.2	0.2	0.2	0.16





TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Læmold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
9 a.m., January 18th, 1896.	-	-	grms. 500	c.c. 500	c.c. Acid	0.48	0.4	0.4	0.6	0.6	0.6	0.52
9 " " 19th "	-	-	500	500	"	0.24	0.0	0.1	0.1	0.1	0.1	0.08
9 " " 20th "	-	-	550	550	"	0.36	0.1	0.2	0.2	0.2	0.3	0.20
9 " " 21st "	-	-	550	550	"	0.30	0.1	0.1	0.1	0.1	0.1	0.10
9 " " 22nd "	-	-	500	500	"	0.36	0.1	0.2	0.2	0.2	0.2	0.18
9 " " 23rd "	-	-	500	500	"	0.48	0.1	0.2	0.4	0.4	0.6	0.34
9 " " 24th "	-	-	500	500	"	0.48	0.2	0.4	0.4	0.4	0.6	0.40
9 " " 25th "	-	-	800	800	"	0.36	0.1	0.2	0.2	0.2	0.2	0.18
9 " " 26th "	-	-	500	500	"	0.48	0.1	0.2	0.2	0.2	0.2	0.18
9 " " 27th "	-	-	500	500	"	0.36	0.1	0.2	0.2	0.4	0.4	0.26
9 " " 28th "	-	-	500	500	"	0.36	0.0	0.1	0.1	0.1	0.1	0.08
9 " " 29th "	-	-	600	600	"	0.36	0.1	0.2	0.2	0.4	0.4	0.26
9 " " 30th "	-	-	500	500	"	0.30	0.1	0.1	0.2	0.2	0.2	0.16
9 " " 31st "	-	-	550	550	"	0.48	0.1	0.2	0.3	0.3	0.3	0.24
9 " February 1st "	-	-	600	600	"	0.36	0.1	0.2	0.2	0.3	0.3	0.22
9 " " 2nd "	-	-	500	500	"	0.36	0.1	0.2	0.2	0.4	0.4	0.26



TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{N}_2\text{S}_2\text{O}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
5—contd.											Average.	
9 a.m., February 26th, 1898.		grams.	c.c. 900	c.c. 900	Acid	0.24	0.1	0.2	0.2	0.3	0.22	
9 " " 27th "		—	800	800	"	0.48	0.4	0.6	0.8	0.8	0.68	
9 " " 28th "		—	800	800	"	0.48	0.0	0.1	0.2	0.2	0.14	
9 " " 29th "		—	800	800	"	0.36	0.1	0.2	0.2	0.2	0.18	
9 " March 1st "		—	1,000	1,000	"	0.30	0.1	0.1	0.1	0.2	0.14	
9 " " 2nd "		—	550	550	"	0.30	0.0	0.1	0.1	0.1	0.08	
9 " " 3rd "		—	800	800	"	0.24	0.1	0.1	0.2	0.2	0.16	
9 " " 4th "		—	1,000	1,000	"	0.20	0.0	0.0	0.1	0.1	0.06	
9 " " 5th "		—	550	550	"	0.36	0.2	0.4	0.4	0.5	0.40	
9 " " 6th "		—	550	550	"	0.24	0.0	0.0	0.1	0.1	0.06	
9 " " 7th "		—	600	600	"	0.20	0.0	0.0	0.0	0.1	0.04	
9 " " 8th "		—	800	800	"	0.24	0.0	0.1	0.1	0.1	0.08	
9 " " 9th "		—	550	550	"	0.30	0.1	0.1	0.1	0.2	0.14	
9 " " 10th "		—	550	550	"	0.30	0.0	0.2	0.3	0.3	0.24	
9 " " 11th "		—	550	550	"	0.30	0.0	0.0	0.1	0.1	0.06	
9 " " 12th "		—	550	550	"	0.24	0.1	0.3	0.4	0.4	0.30	

9 "	13th	600	600	"	0.30	0.0	0.1	0.1	0.1	0.1	0.08
9 "	14th	550	550	"	0.36	0.0	0.0	0.1	0.1	0.1	0.08
9 "	16th	550	550	"	0.46	0.1	0.3	0.3	0.4	0.4	0.30
9 "	16th	550	550	"	0.24	0.0	0.0	0.0	0.1	0.1	0.04
9 "	17th	550	550	Faintly acid.	0.30	Traces.					0.20
9 "	18th	600	600	Acid.	0.30	0.1	0.2	0.2	0.2	0.3	0.08
9 "	18th	500	500	"	0.42	0.0	0.0	0.1	0.1	0.1	0.08
9 "	20th	550	550	Faintly acid.	0.24	Traces.					0.08
9 "	21st	550	550	Acid.	0.30	0.0	0.0	0.1	0.1	0.1	0.14
9 "	22nd	550	550	"	0.42	0.0	0.1	0.2	0.2	0.2	0.10
9 "	23rd	500	500	"	0.24	0.0	0.1	0.1	0.1	0.2	0.10
9 "	24th	550	550	Very faintly acid.	0.18	Traces.					0.28
9 "	25th	500	500	"	0.18	Traces.					0.08
9 "	26th	550	550	Acid	0.42	0.0	0.2	0.4	0.4	0.4	0.08
9 "	27th	550	550	"	0.24	0.0	0.0	0.1	0.1	0.1	0.04
9 "	28th	550	550	"	0.30	0.0	0.0	0.0	0.1	0.1	0.04
9 "	29th	550	550	Very faintly acid.	0.18	Traces.					0.20
9 "	30th	550	550	"	0.18	Traces.					0.18
9 "	31st	600	600	"	0.18	Traces.					0.15
9 "	1st April	550	550	Acid	0.42	0.0	0.2	0.2	0.3	0.3	0.20
9 "	2nd	550	550	"	0.36	0.1	0.2	0.2	0.2	0.2	0.18
9 "	3rd	500	500	"	0.24	0.0	0.1	0.2	0.2	0.1	0.15
9 "	4th	600	600	"	0.36	0.1	0.2	0.2	0.2	0.2	0.15

TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Læmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					Remarks.	
							The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.						
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
5—	9 a.m., April 5th, 1896 .	—	c.c. 600	c.c. 600	Acid	0·36	0·1	0·2	0·2	0·2	0·2	0·18	The sample of peat was obtained from moorland near Settle. Settle water (a hard limestone water) was used instead of distilled water. In this experiment methyl orange was used as an indicator of the amount of the acidity. In all the other experiments described in this table phenolphthalein was used.
cont	9 " " 6th "	—	550	550	"	0·30	0·1	0·1	0·1	0·2	0·2	0·14	
	9 " " 7th "	—	550	550	"	0·24	0·1	0·1	0·1	0·1	0·1	0·10	
	9 " " 8th "	—	550	550	"	0·30	0·1	0·1	0·1	0·2	0·2	0·14	
6	9 a.m., January 30th, 1896. 2,000 grms. Settle peat placed on perforated earthenware disc at foot of cylinder. 8,000 c.c. Settle water (hard limestone water) introduced into cylinder from below upwards.	2,000	8,000	—	—	—	—	—	—	—	—	—	
	12 noon, January 30th, 1896. Settle water allowed to drop into cylinder from above, and collected—after passing through the contents of the cylinder—from overflow pipe, and periodically tested for acidity and plumbo-solvent ability.												
9 a.m., January 31st, 1896	9 " February 1st "	—	1,000	1,000	Acid	No record	0·2	0·4	0·4	0·6	0·8	0·48	Traces.
9 " "	9 " 2nd "	—	1,000	1,000	"	"	0·4	0·6	0·6	0·8	1·0	0·68	
9 " "	9 " 3rd "	—	1,100	1,100	"	0·12	0·4	1·2	1·6	1·6	1·6	1·28	
9 " "	9 " 4th "	—	900	800	"	0·24	1·0	1·0	2·0	2·0	2·0	1·90	

0	"	56h	"	—	900	800	0.24	1.0	2.0	3.0	3.0	2.40
0	"	66h	"	—	1,000	1,000	0.24	1.0	2.0	3.0	3.0	2.40
0	"	76h	"	—	1,000	1,000	0.24	1.0	2.0	3.0	3.0	2.40
0	"	86h	"	—	1,000	1,000	0.24	0.5	1.0	2.0	2.0	1.20
0	"	96h	"	—	800	800	0.24	1.0	1.5	1.5	2.0	1.00
0	"	106h	"	—	1,100	1,100	0.24	1.0	1.5	1.5	2.0	1.20
0	"	116h	"	—	800	800	0.24	1.0	1.5	2.0	2.0	1.20
0	"	126h	"	—	800	800	0.24	1.0	2.0	2.0	2.0	1.80
0	"	136h	"	—	1,300	1,300	0.24	1.0	2.0	2.0	2.5	1.00
0	"	146h	"	—	900	900	0.24	1.0	1.0	1.5	1.5	1.20
0	"	156h	"	—	700	700	0.20	1.0	1.0	1.0	1.5	1.20
0	"	166h	"	—	900	900	0.20	0.5	1.0	1.0	1.5	1.10
0	"	176h	"	—	900	900	0.20	0.5	1.0	1.0	1.5	1.10
0	"	186h	"	—	1,150	1,150	0.24	0.5	1.0	1.5	1.5	1.20
0	"	196h	"	—	1,300	1,300	0.24	1.0	2.0	2.0	2.0	1.80
0	"	206h	"	—	1,000	1,000	0.24	1.0	2.0	2.5	2.5	2.10
0	"	216c	"	—	700	700	neutral	0.5	0.5	0.5	0.5	0.50
0	"	226d	"	—	950	950	0.20	0.8	1.0	1.0	1.0	1.44
0	"	236d	"	—	1,000	1,000	neutral	0.2	0.4	0.4	0.4	0.36
0	"	246h	"	—	1,400	1,400	0.20	0.4	0.8	0.8	0.8	0.72
0	"	256h	"	—	900	900	neutral	0.4	1.2	1.2	1.2	1.04
0	"	266h	"	—	850	850	"	0.2	0.2	0.4	0.4	0.32
0	"	276h	"	—	950	950	"	0.2	0.2	0.4	0.4	0.32

TABLE CXXXVIII.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Cylinder.	Amount of Neutral Water added to Contents of Cylinder.	Amount of Water collected from Overflow Pipe.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). <small>The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 8 Mins. per 50 c.c.</small>					Remarks.
							1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
6— cont.	9 a.m., February 28th, 1893	grms. —	c.c. 1,000	c.c. 1,000	Acid	Neutral	0.4	0.8	1.0	1.0	1.0	0.84
9	" " 28th "	—	750	750	"	"	0.2	0.2	0.2	0.2	0.2	0.20
9	" March 1st, 1893	—	1,000	1,000	"	Neutral	0.2	0.2	0.2	0.2	0.3	0.22
9	" " 2nd "	—	1,000	1,000	"	"	0.1	0.2	0.2	0.2	0.2	0.18
9	" " 3rd "	—	850	850	"	"	0.1	0.2	0.2	0.2	0.2	0.18
9	" " 4th "	—	900	900	"	"	0.1	0.2	0.2	0.2	0.2	0.18
9	" " 5th "	—	1,000	1,000	"	"	0.08	0.1	0.1	0.1	0.2	0.11
9	" " 6th "	—	1,000	1,000	"	"	0.08	0.1	0.1	0.15	0.15	0.11
9	" " 7th "	—	800	800	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9	" " 8th "	—	1,000	1,000	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9	" " 9th "	—	900	900	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9	" " 10th "	—	1,000	1,000	"	"	0.1	0.3	0.3	0.3	0.3	0.26
9	" " 11th "	—	800	800	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9	" " 12th "	—	1,000	1,000	"	"	0.1	0.2	0.2	0.2	0.2	0.18
9	" " 13th "	—	800	800	"	"	0.0	0.1	0.1	0.2	0.2	0.12
9	" " 14th "	—	1,000	1,000	"	"	0.1	0.2	0.2	0.2	0.2	0.20

9 "	15th "	"	—	800	800	"	"	0.3	0.2	0.3	0.3	0.3	0.20
9 "	16th "	"	—	1,000	1,000	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	17th "	"	—	1,000	1,000	"	"	0.0	0.0	0.1	0.1	0.1	0.08
9 "	18th "	"	—	850	850	"	"	0.0	0.0	0.1	0.1	0.1	0.08
9 "	19th "	"	—	900	900	"	"	0.1	0.1	0.3	0.3	0.2	0.16
9 "	20th "	"	—	2,000	2,000	Paintlyacid	"	0.1	0.1	0.1	0.1	0.1	0.10
9 "	21st "	"	—	1,000	1,000	"	"	0.1	0.1	0.1	0.1	0.1	0.10
9 "	22nd "	"	—	1,000	1,000	"	"	0.1	0.1	0.1	0.1	0.1	0.10
9 "	23rd "	"	—	700	700	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	24th "	"	—	1,000	1,000	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	25th "	"	—	950	950	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	26th "	"	—	800	800	? acid	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	27th "	"	—	900	900	Paintlyacid	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	28th "	"	—	900	900	? acid	"	0.0	0.0	? traces.	0.1	0.1	0.08
9 "	29th "	"	—	1,000	1,000	"	"	0.0	0.0	0.0	0.1	0.1	0.08
9 "	30th "	"	—	900	900	"	"	0.0	0.0	0.0	0.1	0.1	0.08
9 "	31st "	"	—	700	700	"	"	0.0	0.0	0.0	0.1	0.1	0.08
9 "	April 1st	"	—	750	750	? trace acid	"	0.1	0.2	0.3	0.3	0.2	0.20
9 "	2nd "	"	—	900	900	? acid	"	0.1	0.1	0.1	0.2	0.2	0.14
9 "	3rd "	"	—	900	900	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	4th "	"	—	900	900	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	5th "	"	—	750	750	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	6th "	"	—	700	700	"	"	0.0	0.1	0.1	0.1	0.1	0.08
9 "	7th "	"	—	1,000	1,000	"	"	0.0	0.1	0.1	0.1	0.1	0.08



The conditions of experiment are fully stated in the table (Table CXXXVIII., *see also* Fig. 9, Plate VI.) and need not here be repeated.

In Experiment 1, 1,000 grammes of Settle peat were left in prolonged contact with 7,700 c.c. of water, and during July (part of), August, September, and October (part of), 1895, water was slowly, but continuously, from above downward, filtered through it. Altogether, during this period, 117,630 c.c. of neutral distilled water were passed through the peat, making, with the 7,700 c.c. above alluded to, a total of 125,300 c.c. rendered acid and plumbo-solvent in character by contact with the peat (1 part of peat to 125 parts of water).

In Experiment 2, Ribble river water (which is possessed of an appreciable degree of acid-neutralising ability) was used instead of distilled water. The experiment lasted from July 20th to October 8th, 1895. Altogether 131,530 c.c. of river water were, by this filtration, rendered acid and plumbo-solvent in character (1 part of peat to 131 parts of water).

In Experiment 3, 1,000 grammes of Huddersfield peat were used. The experiment lasted from August 5th, 1895, to October 8th, 1895. The peat conferred acid and plumbo-solvent properties on 84,730 c.c. of neutral distilled water (1 part of peat to 84 parts of water).

In Experiment 4, 100 grammes of Halifax peat were used. The experiment lasted from September 13th to October 15th, 1895. Altogether 47,900 c.c. of water were rendered acid and plumbo-solvent in character (1 part of peat to 479 parts of water).

In Experiment 5, rain-water, instead of distilled water, was filtered through 500 grammes of Halifax peat. The experiment lasted from October 8th, 1895, to April 8th, 1896. During a short period (January 7th to 14th) the water was stopped dropping in from above. The peat conferred acid and plumbo-solvent properties on 129,000 c.c. of rain-water (1 part of peat to 258 parts of water).

In Experiment 6, 2,000 grammes of Settle peat were used and Settle water (a hard limestone water, possessed of considerable acid-neutralising ability) was employed instead of distilled water. The experiment lasted from January 30th, 1896, to April 7th, 1896. Altogether about 72,100 c.c. of Settle water were rendered acid and plumbo-solvent in character (1 part of peat to 36 parts of water).

The above prolonged series of experiments serves well to illustrate the remarkable power possessed by peat of rendering acid and plumbo-solvent in character a relatively large volume of neutral water. On most moorland gathering grounds there are, on the upper and flatter portions of the drainage area, hollows and depressions where the rain accumulates in the peat, and where, even in dry weather, the peat is apt to remain saturated with water, and from these pools peaty water drains into the waterworks, either continuously or intermittently, according to the season of the year and the amount of rainfall. The experiments that have been here described were designed to imitate as nearly as possible natural conditions, and they serve to show, in a striking manner, the potentially dangerous qualities of peat as regards its power of rendering water acid and plumbo-solvent.

A long series of experiments (Table CXXXIX., Fig. 8, Plate V.) may next be considered. A measured quantity of peat (ten grammes) was tied up in a muslin bag and added in each case to 500 c.c. of neutral distilled water and the mixture kept for varying periods in stoppered bottles. The acidity and plumbo-solvency of the liquid were tested in the usual manner.

# Plate VII

Vessel containing neutral distilled water; water allowed to drop continuously into cylinder

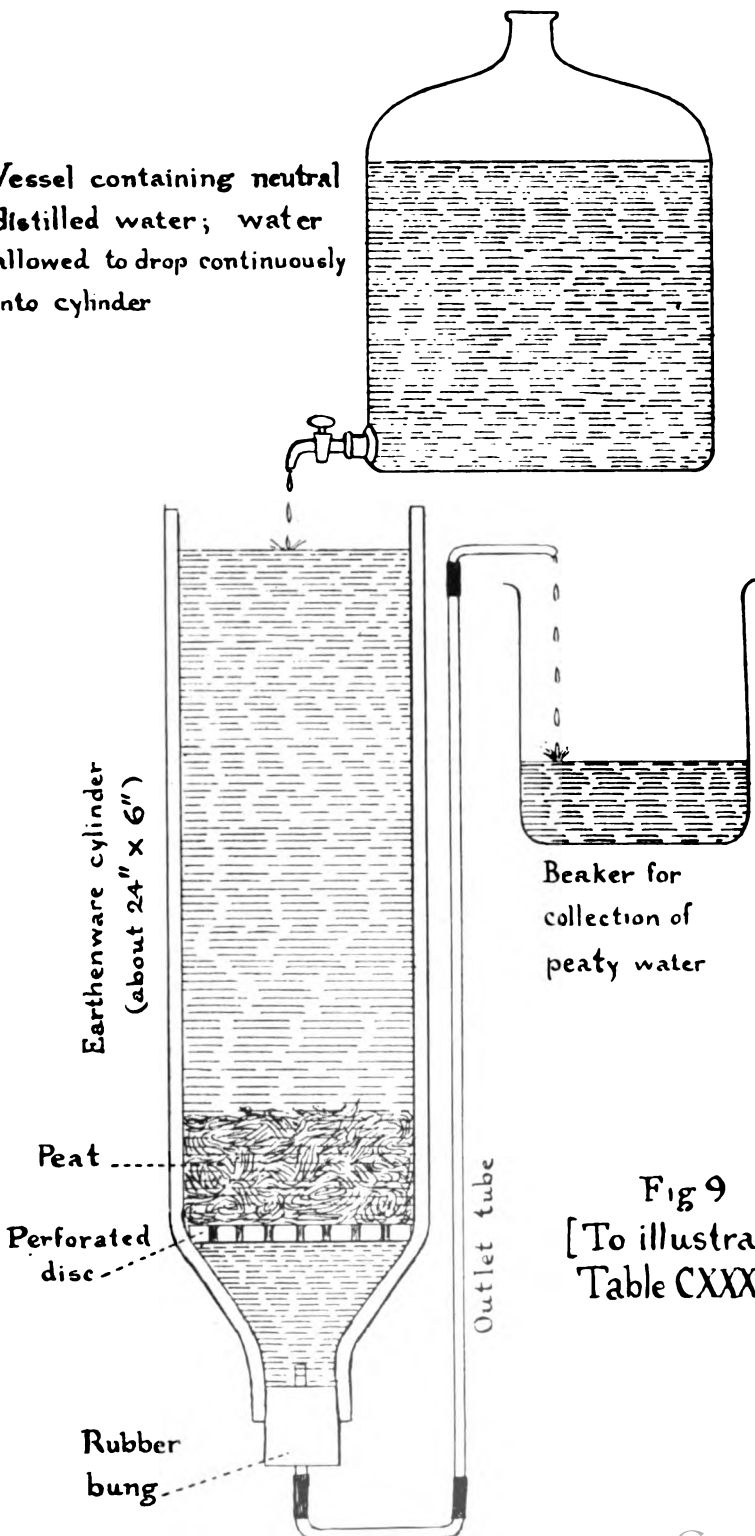


Fig 9  
[To illustrate  
Table CXXXVIII]



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**TABLE CXXXIX.**

**Showing the EFFECT, as regards ACIDITY and ACTION on LEAD, of adding PEAT to DISTILLED WATER, and keeping the Mixture for varying Periods in Stoppered Bottle with Air-space (*see* Plate V., Fig. 8).**

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TABLE CXXXIX.

Showing the EFFECT, as regards ACIDITY and ACTION on LEAD, of adding PEAT to DISTILLED WATER, and keeping the Mixture for varying Periods in Stopped Bottle with Air-space (see Plate V., Fig. 8).

[The peat was tied up in a muslin bag, and the distilled water was previously boiled. The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 mins. per 50 c.c.]

No. of Experiment.	Description of the Experiment.	(a) & (b). Tested after	Acidity :—		Action on Lead (Results stated as Parts per 100,000).					Remarks.	
			Reaction with Lacmoid.	In Terms of c.c. % $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
1	November 28th, 1894 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	Days. 3 {	(a.) Acid - (b.) Neutral	0.30 0.12†	0.2 0.0	0.4 0.0	0.5 0.0	0.6 0.0	0.6 0.0	The sample of peat was obtained from moorland near Settle.	
2	November 30th, 1894 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	8 {	(a.) Acid - (b.) Neutral	0.96 0.13	0.2 0.0	0.4 0.0	0.4 0.0	0.6 0.0	0.6 0.0		
3	December 3rd, 1894 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	8 {	(a.) Acid - (b.) Neutral	0.73 0.12	0.0 0.0	0.2 0.0	0.4 0.0	0.4 0.0	0.5 0.0		
4	December 12th, 1894 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	5 {	(a.) Acid - (b.) Neutral	0.72 0.12	0.1 0.0	0.4 0.0	0.5 0.0	0.6 0.0	0.6 0.0		
5	December 12th, 1894 :— (a.) 5 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	9 {	(a.) Acid - (b.) Neutral	0.73 0.12	0.2 0.0	0.6 0.0	0.8 0.0	0.8 0.0	1.0 0.0	The sample of peat was obtained from moorland on the gathering ground of the Shipley water supply.	

6	December 13th, 1894 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	7 { (a.) Acid - (b.) Neutral	0.84 0.12	0.2 0.0	0.4 0.0	0.6 0.0	0.6 0.0	0.6 0.0	0.48 0.00
7	January 16th, 1895 :— (a.) 5 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	14 { (a.) Acid - (b.) Neutral	0.24 0.12	0.1 0.0	0.2 0.0	0.2 0.0	0.2 0.0	0.2 0.0	0.18 0.00
8	January 30th, 1895 :— (a.) 10 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	8 { (a.) Acid - (b.) Neutral	0.30 0.12	0.0 0.0	0.2 0.0	0.2 0.0	0.2 0.0	0.2 0.0	0.16 0.00
9	February 6th, 1895 :— (a.) 10 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	7 { (a.) Acid - (b.) Neutral	0.24 0.12	0.0 0.0	0.0 0.0	0.1 0.0	0.2 0.0	0.2 0.0	0.10 0.00
10	March 4th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	5 { (a.) Acid - (b.) Neutral	0.36 0.12	0.05 0.0	0.1 0.0	0.2 0.0	0.2 0.0	0.4 0.0	0.21 0.00
11	March 6th, 1895 :— (a.) 10 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	8 { (a.) Acid - (b.) Neutral	0.48 0.12	0.0 0.0	0.1 0.0	0.2 0.0	0.2 0.0	0.2 0.0	0.16 0.00
12	March 13th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	6 { (a.) Acid - (b.) Neutral	0.48 0.12	0.0 0.0	0.1 0.0	0.2 0.0	0.2 0.0	0.4 0.0	0.20 0.00
13	March 16th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	9 { (a.) Acid - (b.) Neutral	0.72 0.12	0.2 0.0	0.4 0.0	0.5 0.0	0.5 0.0	0.6 0.0	0.44 0.00
14	March 20th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	10 { (a.) Acid - (b.) Neutral	0.72 0.12	0.2 0.0	0.4 0.0	0.5 0.0	0.5 0.0	0.6 0.0	0.44 0.00
15	March 22nd, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	13 { (a.) Acid - (b.) Neutral	0.96 0.12	0.2 0.0	0.4 0.0	0.6 0.0	0.6 0.0	0.8 0.0	0.56 0.00
16	March 28th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	20 { (a.) Acid - (b.) Neutral	0.72 0.12	0.2 0.0	0.4 0.0	0.6 0.0	0.6 0.0	0.6 0.0	0.48 0.00
17	April 3rd, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	16 { (a.) Acid - (b.) Neutral	1.08 0.12	0.2 0.0	0.6 0.0	0.8 0.0	0.8 0.0	0.9 0.0	0.66 0.00

TABLE CXXXIX.—*continued.*

No. of Experiment.	Description of the Experiment.	'a.) & (b). Tested after	Acidity :— Reaction with Lacmoid.	In Terms of c.c. 10 Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000).					Remarks.
					1st 30 c.c.	2nd 30 c.c.	3rd 30 c.c.	4th 30 c.c.	5th 30 c.c.	
					Average.					
18	April 5th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	17 {	(a.) Acid - (b.) Neutral	1.44 0.12	0.3 0.0	0.7 0.0	0.9 0.0	1.1 0.0	1.1 0.0	0.82 0.00
19	April 10th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	15 {	(a.) Acid - (b.) Neutral	0.84 0.12	0.2 0.0	0.6 0.0	0.8 0.0	0.8 0.0	0.8 0.0	0.65 0.00
20	April 15th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	1 {	(a.) Acid - (b.) Neutral	0.30 0.12	0.0 0.0	0.0 0.0	0.0 0.0	0.1 0.0	0.1 0.0	0.04 0.00
21	April 20th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	25 {	(a.) Acid - (b.) Neutral	1.32 0.12	0.2 0.0	0.5 0.0	0.6 0.0	0.6 0.0	0.6 0.0	0.50 0.00
22	April 22nd, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	35 {	(a.) Acid - (b.) Neutral	2.76 0.12	1.0 0.0	1.6 0.0	1.8 0.0	1.8 0.0	1.8 0.0	1.40 0.00
23	April 23rd, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	30 {	(a.) Acid - (b.) Neutral	2.88 0.12	1.2 0.0	1.6 0.0	1.6 0.0	1.8 0.0	1.8 0.0	1.40 0.00
24	April 25th, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	40 {	(a.) Acid - (b.) Neutral	0.94 0.12	0.2 0.0	0.4 0.0	0.5 0.0	0.5 0.0	0.6 0.0	0.44 0.00
25	May 2nd, 1895 :— (a.) 10 grms. Settle peat in 500 c.c. distilled water - - - (b.) 500 c.c. of the same distilled water (control experiment)	2 {	(a.) Acid - (b.) Neutral	0.30 0.12	0.0 0.0	0.0 0.0	0.0 0.0	0.1 0.0	0.1 0.0	0.04 0.00

26	May 12th, 1896 :— (a.) 10 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	6 { (a.) Acid - (b.) Neutral	0.60 0.12	0.0 0.0	0.1 0.0	0.2 0.0	0.2 0.0	0.14 0.00	
27*	May 13th, 1896 :— (a.) 10 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	11 { (a.) Acid - (b.) Neutral	1.80 0.12	0.1 0.0	0.2 0.0	0.2 0.0	0.3 0.0	0.20 0.00	
28†	May 24th, 1896 :— (a.) 10 grms. Shipley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	15 { (a.) Acid - (b.) Neutral		See footnote.					
29	May 30th, 1896 :— (a.) 10 grms. Keighley peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	13 { (a.) Acid - (b.) Neutral	0.60 0.12	0.2 0.0	0.6 0.0	0.7 0.0	0.8 0.0	0.62 0.00	The sample of peat was obtained from moorland on the gathering ground of Keighley water supply.
30	June 18th, 1896 :— (a.) 10 grms. Sheffield peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	13 { (a.) Acid - (b.) Neutral	1.08 0.12	0.6 0.0	0.8 0.0	0.9 0.0	1.0 0.0	0.86 0.00	The sample of peat was obtained from moorland on the gathering ground of the Sheffield water supply.
31	March 16th, 1896 :— (a.) 10 grms. Blackburn peat in 500 c.c. distilled water - (b.) 500 c.c. of the same distilled water (control experiment)	17 { (a.) Acid - (b.) Neutral	0.72 0.12	0.1 0.0	0.3 0.0	0.4 0.0	0.4 0.0	0.32 0.00	The sample of peat was obtained from moorland on the gathering ground of the Blackburn water supply.

\* The dark colour of sample made it difficult to estimate the action on lead.

† The sample was so dark in colour (no doubt due, in part, to the presence of iron) that the estimation of the acidity and the action on lead was rendered extremely difficult. With regard to the acidity 10 c.c. of the sample was diluted with distilled water and required 0.78 c.c.  $\frac{N}{10}$   $\text{Na}_2\text{CO}_3$  (phenol-phthalein as indicator).



TABLE CXXXIX.—continued.

No. of Experiment.	Description of the Experiment.	(a) & (b). Tested after	Acidity :—		Action on Lead (Results stated as Parts per 100,000).					Remarks.
			Reaction with Lacmoid.	In Terms of c.c. % $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	
32	March 30th, 1890 :— (a.) 10 grms. Burnley peat in 500 c.c. distilled water. (b.) 500 c.c. of the same distilled water (control experiment)	Days. 13 {	(a.) Acid (b.) Neutral	0.54 0.12	0.3 0.0	0.5 0.0	0.6 0.0	0.8 0.0	0.8 0.0	The sample of peat was obtained from moorland on the gather- ing ground of the Burnley water supply.
33	April 3rd, 1890 :— (a.) 10 grms. Bacup peat in 500 c.c. distilled water (b.) 500 c.c. of the same distilled water (control experiment)	9 {	(a.) Acid (b.) Neutral	0.90 0.12	0.8 0.0	1.3 0.0	1.2 0.0	1.2 0.0	1.13 0.00	The sample of peat was obtained from moorland on the gather- ing ground of the Bacup water supply.

From was usually found in the samples, and in Experiments 32, 27, 28, amounted to 0.1, 0.2, 0.6 parts per 100,000 respectively.  
 ‡ 100 c.c. of a neutral water usually requires 0.12 c.c. %  $\text{Na}_2\text{CO}_3$  to give a pink colour with phenol-phthalein as indicator.

It will be noted that 38 experiments were carried out with peat from Settle, Shipley, Keighley, Sheffield, Blackburn, Burnley, and Bacup. In all cases the water acquired from the peat acidity and plumbo-solvent ability; and the experiments conclusively show that 1 part of peat can render at least 50 parts of water dangerous, as far as these properties are concerned. Within certain limits the longer the contact of the water with the peat, the greater usually was the acidity and plumbo-solvent ability developed. But, as a rule, even a few days' contact sufficed to render the water appreciably acid and plumbo-solvent in character.

In the following table (Table CXL.) the effect, as regards acidity and plumbo-solvency, of filtering a hard limestone water through peat is shown :—

TABLE CXL.

Showing the EFFECT, as regards ACIDITY and PLUMBO-SOLVENCY, of filtering a HARD LIMESTONE WATER through PEAT.

Number.	Date.	Description of Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. " $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.		Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Shot at the Rate of 3 mins. per 50 c.c.					
				Indicator.		1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
				Phenol- phthalain.	Methyl-orange.						
1	1886. Aug. 26	100 grms. Huddersfield peat in double muslin filter. 1,000 c.c. Settle water filtered through very slowly. The filtrate tested for acidity and plumbo-solvency.	Acid	0.96	0.24	0.4	0.9	1.0	1.1	1.1	0.9
2	1886. Jan. 31	100 grms. Settle peat in double muslin filter. 1,000 c.c. Settle water filtered through very slowly. The filtrate tested for acidity and plumbo-solvency.	"	0.48	Here the reaction was neutral, but only 0.3 c.c. $\frac{1}{10}$ $\text{H}_2\text{SO}_4$ was needed to be added to give the filtrate an acid reaction, whereas 3.0 c.c. $\frac{1}{10}$ $\text{H}_2\text{SO}_4$ were needed to give Settle water an acid reaction.	0.2	0.3	0.4	0.4	0.6	0.38

Settle water is a water possessed of a considerable degree of acid-neutralising ability; yet it is evident that, under the conditions of the experiments, 100 grammes of peat sufficed to render acid and plumbo-solvent in character 1,000 c.c. of Settle water

In considering the question of acidity, apart from plumbo-solvency, a number of experiments were described in which the addition of sulphide of iron, iron pyrites, and shale to peat was made. The following table (Table CXLI.) might have with justice been then considered; but its detailed discussion has been reserved for this place, since it deals with plumbo-solvency as well as acidity:—

TABLE CXLI.

Showing the EFFECT, as regards ACIDITY and PLUMBO-SOLVENCY, of filtering NON-PLUMBO-SOLVENT WATER through PEAT to which certain SUBSTANCES had been added.

A double layer of muslin was placed in a large funnel and the peat packed inside. Water was then started slowly dropping on to the peat in the funnel. A small piece of filter paper was put on the surface of the peat to "spread" the water dropping in. The water after filtering through the peat was collected in a suitable vessel and periodically examined for acidity and plumbo-solvent ability.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel	Amount of Water filtered through the Peat.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.					Remarks.	
						1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		
						Average.						
1 A	Experiment started 11 a.m. October 21st, 1895. 200 grms. Mossley peat + 0 in double muslin filter in funnel. Rain-water (neutral and free from plumbo-solvent ability) filtered slowly through the peat. Filtrate tested every second day for acidity and plumbo-solvency. The peat was retested every second day. Control experiment to 1 B.	200 grms. Mossley peat + 0.	c.c. 1,200 3,500 1,400 1,650 1,500 1,400 2,400 800	Acid " " " " " " "	0.96 0.80 0.30 0.54 0.42 0.24 0.24 0.43	2.0 0.0 0.1 0.6 0.4 0.0 0.0 0.2	3.5 0.1 0.2 1.2 0.8 0.0 0.1 0.4	3.5 0.1 0.3 1.2 0.8 0.1 0.1 0.4	4.0 0.2 0.4 1.4 1.0 0.1 0.1 0.4	4.0 0.2 0.5 1.4 1.0 0.1 0.1 0.5	3.40 0.12 0.30 1.12 0.80 0.06 0.08 0.38	The sample of peat was obtained from the moorland gathering ground of Mossley water supply.

1 B	Experiment started 11 a.m. October 2nd, 1896. Conditions same as in Experiment 1A, but 2 grms. sulphide of iron (FeS) first added to the peat.	200 grms. Mossy peat + 2 grms. FeS	1,100	"	0.84	0.5	1.2	1.3	1.2	1.12	In both 1A and 1B iron was present in the fl.trate.
			2,500	"	0.80	0.2	0.2	0.2	0.3	0.22	
			2,000	"	0.54	0.1	0.3	0.2	0.3	0.24	
			1,070	"	0.72	0.3	0.4	0.5	0.6	0.46	
			1,700	"	0.30	0.1	0.1	0.1	0.1	0.10	
			1,350	"	0.36	0.1	0.2	0.2	0.3	0.20	
			500	"	0.46	0.1	0.2	0.2	0.3	0.20	
			1,300	"	0.46	0.1	0.4	0.4	0.5	0.38	
2 A	Experiment started March 3rd, 1896, 100 grms. Settle peat + 0 in muslin in funnel. Distilled water (neutral and free from plumbo-solvent ability) filtered slowly through the peat. Control experiment to 2B and 3C.	100 grms. Settle peat + 0.	—	—	—	—	—	—	—	—	The sample of peat was obtained from morland near Settle.
	Between —										
	March 3rd and March 4th (24 hours).		1,000	Acid	0.30	0.2	0.4	0.4	0.5	0.40	
	" 6th "	" 7th "	800	"	0.30	0.1	0.3	0.3	0.3	0.26	
	" 9th "	" 10th "	800	"	0.30	0.1	0.1	0.1	0.1	0.12	
	" 13th "	" 14th "	800	"	0.30	0.1	0.1	0.2	0.2	0.16	
	" 14th "	" 16th "	800	Pt. acid	0.18			Traces.			
	" 18th "	" 20th "	800	"	0.24	0.1	0.1	0.1	0.1	0.10	
	" 20th "	" 21st "	800	"	0.18			Traces.			
	" 23th "	" 24th "	800	"	0.18	0.0	0.1	0.1	0.1	0.08	
	" 26th "	" 27th "	750	"	0.18	0.0	0.1	0.1	0.1	0.08	
	" 31st and April 1st		800	Acid	0.24	0.1	0.2	0.2	0.2	0.18	
	April 1st	" 2nd "	800	"	0.20	0.1	0.1	0.1	0.2	0.14	

TABLE CXLI.—continued.

Experiment.	Description of the Experiment.	Amount of Peat in the Funnel.	Amount of Water filtered through the Peat.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 min. per 50 c.c.					Remarks.
						1st	2nd	3rd	4th	5th	
						50 c.c.	50 c.c.	50 c.c.	50 c.c.	50 c.c.	
2 B	Experiment started March 4th, 1896. Conditions same as in Experiment 2A, but 1 grm. iron pyrites ( $\text{FeS}_2$ ) powdered first added to the peat. Between—	100 grms. Settle peat + 1 grm. $\text{FeS}_2$ (powdered iron pyrites).	c.c.								
	March 4th and March 5th, 1896	—	800	Acid	0.46	0.1	0.5	0.5	0.6	0.6	0.46
	" 7th " 8th "	—	800	"	0.20	0.1	0.2	0.2	0.2	0.3	0.20
	" 10th " 11th "	—	800	Pt. acid	0.24	0.1	0.2	0.2	0.2	0.2	0.18
	" 15th " 16th "	—	800	Acid	0.36	0.1	0.2	0.2	0.3	0.3	0.22
	" 16th " 17th "	—	825	Pt. acid	0.18	Traces.					
	" 21st " 22nd "	—	850	"	0.24	0.1	0.2	0.2	0.2	0.2	0.18
	" 22nd " 23rd "	—	900	"	0.18	0.0	0.0	0.1	0.1	0.1	0.06
	" 27th " 28th "	—	800	Acid	0.26	0.1	0.2	0.2	0.2	0.2	0.18
	" 28th " 29th "	—	800	Pt. acid	0.15	0.0	0.0	0.0	0.1	0.1	0.04
	April 2nd and April 3rd	—	500	Acid	0.30	0.1	0.1	0.2	0.2	0.2	0.16
	" 3rd " 4th "	—	800	Pt. acid	0.18	Traces.					

2 C	Experiment started March 5th, 1896. Conditions same as in Experiment 2 A, but 1 grm. powdered shale first added to the peat.	100 grms. Settle peat + 1 grm. powdered shale.	800	Pt. acid	0.20	0.1	0.2	0.3	0.3	0.3	0.24
Between— March 5th and March 6th, 1896			800	Acid	0.20	0.1	0.2	0.3	0.3	0.3	0.24
" 8th "	9th "	—	800	Acid	0.20	0.1	0.2	0.2	0.2	0.2	0.18
" 11th "	12th "	—	800	Pt. acid	0.20	0.1	0.2	0.2	0.2	0.2	0.18
" 12th "	13th "	—	800	V. ft. acid	0.18	0.0	0.1	0.1	0.1	0.1	0.08
" 17th "	18th "	—	850	"	0.18	0.0	0.0	0.0	0.1	0.1	0.04
" 18th "	19th "	—	800	"	0.15			Traces.			
" 23rd "	24th "	—	850	"	0.18	0.0	0.1	0.1	0.1	0.1	0.08
" 24th "	25th "	—	850	"	0.18			Traces.			
" 29th "	30th "	—	750	"	0.18	0.0	0.1	0.1	0.1	0.1	0.08
" 30th "	31st "	—	750	"	0.15			Traces.			
April 4th and April 5th, 1896		—	700	"	0.18	0.1	0.1	0.1	0.1	0.1	0.10

In Experiment 1A and 1B the filtrate from peat alone was seemingly as acid and plumbo-solvent in character as the filtrate from peat mixed with 1 per cent. of sulphide of iron.

In Experiments 2A, 2B and 2C peat alone, peat mixed with iron pyrites, and peat mixed with powdered shale were under experiment. The shale seemed, if anything, to lessen the acid and plumbo-solvent qualities of the peat filtrate. The addition of iron pyrites appeared to have a slight, but by no means noteworthy, effect in the way of increasing the acidity and plumbo solvent ability of the filtrate from the heat.

The following two tables (CXLII. and CXLIII.) show, as regards acidity and plumbo-solvency, the result of certain experiments with (a) peat containing a large amount of iron, and (b) peat containing apparently no iron (Table CXLII.); and the effect, as regards acidity, of filtering distilled water through (a) peat + 0 and through (b) peat + "iron ore" (Table CXLIII.).

TABLE CXLII.

Showing, as regards ACIDITY and PLUMBO-SOLVENCY, the Result of certain EXPERIMENTS with (a) PEAT containing a large Amount of IRON, and (b) PEAT containing apparently no IRON.

Experiment.	Date.	Description of Experiment.	Reaction with Lactmold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Action on Lead (Results stated as Parts per 100,000). The Action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.				
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.
1	1895. Aug. 28th	25 grms. Bradford peat (from "low level" gathering ground), which showed distinctly the presence* of iron in a double muslin filter. 500 c.c. boiled distilled water (neutral and free from plumbo-solvent ability), slowly filtered through the peat, and the filtrate tested for acidity and plumbo-solvency.	? Trace of acid.	0.12	0.0	0.0	0.0	0.0	0.0
2	"	Same as Experiment 1, but the peat, which was collected from a spot close to the sample used in Experiment 1, contained, as far as could be seen, no iron.	? Trace of acid.	0.18			Traces.		

\* The sample was obtained from a bed of peat which showed the presence of iron in the form of an ochre-like deposit.

These samples of peat collected for the experiments were unfortunately not possessed of any decided power of rendering water acid and plumbo-solvent in character. But certainly the peat rich in iron deposit had no greater ability to produce this result than the peat seemingly free from the presence of iron.

TABLE CXLIII.

Showing the EFFECT, as regards ACIDITY, of FILTERING DISTILLED WATER through (a) PEAT + 0 and through (b) PEAT + "IRON ORE."\*

Experiment.	Date.	Description of the Experiment.	Reaction with Lac-moid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.
1a	1895. July 30th	10 grms. Settle peat + 0 in double muslin filter. 100 c.c. distilled water (previously boiled and neutral in reaction), slowly filtered through the peat. The filtrate tested for acidity.	Acid	0.54
1b	"	Same as 1a, but 1 gm. "iron ore" mixed with the peat.	"	0.60
2a	July 31st	100 c.c. distilled water, filtered through the same peat, as in 1a.	"	0.24
2b	"	100 c.c. distilled water, filtered through the same peat, as in 1b.	"	0.30
3a	Aug. 1st	100 c.c. distilled water, again filtered through the same peat, as in 1a.	"	0.24
3b	"	100 c.c. distilled water, again filtered through the same peat, as in 1b.	"	0.24
4a	Aug. 2nd	100 c.c. distilled water, again filtered through the same peat, as in 1a.	"	0.18
4b	"	100 c.c. distilled water, again filtered through the same peat, as in 1b.	"	0.18
5a	Aug. 5th	100 c.c. distilled water, again filtered through the same peat, as in 1a.	"	0.18
5b	"	100 c.c. distilled water, again filtered through the same peat, as in 1b.	"	0.18

\* Scraped from the surface of the marl in the feeders on the Shipley moorland gathering grounds.

It will be observed that under the conditions of experiment the peat + "iron ore" had no appreciably greater power of rendering its filtrate acid than had the peat alone.

The following table (CXLIV.) shows the effect, as regards acidity and plumbo-solvency, of heating peat to 100° C. for some time, and of then filtering through it distilled water.



TABLE CXLIV.

Showing the EFFECT, as regards ACIDITY and PLUMBO-SOLVENCY, of HEATING PEAT to 100° C. for some Time, and then filtering DISTILLED WATER through it.

Number.	Date.	Description of Experiment.	Reaction with Læmold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Parts per 100,000). The Action on Lead was tested by Upward Filtration through 50 c.c. washed Lead Shot.				
					1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th Average.
1a	1895. Aug. 7	100 grms. Huddersfield peat in double muslin filter. 100 c.c. boiled neutral distilled water (free from plumbo-solvent ability) filtered slowly through the peat. The filtrate tested for acidity.	Acid	1.68	—	—	—	—	—
1b	"	Same as 1a, but the peat previously heated to 100° C. for three hours in steam steriliser.	"	8.40	—	—	—	—	—
2a	Aug. 8	500 c.c. boiled distilled water (neutral and free from plumbo-solvent ability) filtered slowly through the same peat as in 1a, and the filtrate tested for acidity and plumbo-solvent ability.	"	0.00	0.4	1.0	1.2	1.2	1.0
2b	"	500 c.c. boiled distilled water (neutral and free from plumbo-solvent ability) filtered through the same peat as in 1a, and the filtrate tested for acidity and plumbo-solvent ability.	"	1.44	2.0	2.0	3.0	3.0	2.6
3a	Aug. 17	Same as 2a	"	0.00	0.4	0.8	1.2	1.2	0.168
3b	"	Same as 2b	"	1.80	1.5	3.0	3.0	3.5	2.90

It will be noted that heating the peat to 100° C. previous to the filtration process undoubtedly increased the acidity and plumbo-solvent ability of the filtrate. This might lend colour to the view that the acidity of peaty water is dependent solely on chemical or physical changes rather than on biological processes. But there seems no reason to assert that what can be effected rapidly by heat cannot also, although more slowly, be effected by bacteria.

The following table (Table CXLV.) shows the effect, as regards acidity and plumbo-solvent ability, of filtering distilled water (a) through peat freshly collected and (b) through the same peat after the peat had been kept for some considerable time in a moist chamber.

TABLE CXLV.

Showing the RESULT, as regards ACIDITY and PLUMBO-SOLVENT ABILITY, of filtering DISTILLED WATER through PEAT freshly collected, and through the same PEAT after being kept for some considerable Time in a MOIST CHAMBER.

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of cc. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by upward filtration through 50 c.c. washed Lead Shot at the rate of 3 min. per 50 c.c.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1	February 20th, 1896. 50 grms. Settle peat in double muslin filter. 500 c.c. boiled distilled water (neutral and free from plumbo-solvent ability) filtered through the peat at the rate of 33 seconds per 10 c.c.	Acid	0.49	0.1	0.4	0.4	0.5	0.5	0.38
2	Same as Experiment 1, but the peat was kept for three months in a moist chamber with a large air space.	..	0.72	0.4	0.6	0.8	1.0	1.0	0.75

It is to be regretted that more experiments were not carried out under this heading; but, so far as deductions may be drawn from an isolated experiment, the results seem to show that keeping peat for some time with a large air space in a moist chamber confers on the peat an increased power of yielding acid and plumbo-solvent properties to neutral water filtered through it.

The following table (CXLVI.) shows the effect of filtering distilled water through peat, as regards the acidity and plumbo-solvency of the filtrate, and also the result of keeping the filtrate (neutralised and not neutralised) for varying periods of time in partially filled and stoppered bottles and also in completely filled and stoppered bottles.

TABLE CXLVI.

Showing the EFFECT of filtering NEUTRAL DISTILLED WATER through PEAT, as regards the ACIDITY and PLUMBO-SOLVENCY of the Filtrate; and also the Result of keeping the Filtrate for varying Periods of Time in (a), partially filled and stoppered Bottle; (b), partially filled and stoppered Bottle, but neutralised  $\frac{n}{10}$   $\text{Na}_2\text{CO}_3$ ; (c), completely filled and stoppered Bottle; (d), completely filled and stoppered Bottle, but neutralised  $\frac{n}{10}$   $\text{Na}_2\text{CO}_3$ .

[The distilled water was previously boiled. The action on lead was tested by means of upward filtration through 50 c.c. washed lead shot at a uniform rate of 3 mins. per 50 c.c.]

Experiment.	Description of the Experiment.	Tested after	Acidity:—		Action on Lead (Results stated as Parts per 100,000).				
			Reaction with Læmoid.	In Terms of c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c. Average.
1	April 9th, 1895:— (a.) 100 grms. Settle peat in double muslin filter. 1,000 c.c. neutral distilled water filtered through very slowly. Filtrate tested for acidity and plumbo-solvency. (b.) Some of the filtrate kept in partially filled and stoppered bottle for some time.	Days. (a.) Same day (b.) 18 days	Acid faint Acid distinct	0.19 0.34	0.0	0.05	0.1	0.1	0.07
2	April 10th, 1895:— (a.) Same as (a), Experiment I. (b.) Same as (b), Experiment I.	(a.) Same day (b.) 17 days	Acid distinct "	0.34 0.34	0.1 0.0	0.2 0.0	0.1 0.0	0.1 0.05	0.18 0.03
3	April 13th, 1895:— (a.) Same as (a), Experiment I. (b.) Same as (b), Experiment I.	(a.) Same day (b.) 17 days	Acid faint "	0.18 0.18	0.0	0.1 Traces.	0.1	0.1	0.08
4	April 16th, 1895:— (a.) Same as (a), Experiment I. (b.) Same as (b), Experiment I.	(a.) Same day (b.) 8 days	Acid distinct "	0.30 0.36	0.0	0.1	0.2 No record.	0.2	0.14

5	April 22nd, 1895 :— (a.) Same as (a), Experiment I. - (b.) Same as (b), Experiment I. -	-	-	-	-	-	-	-	0.1	0.2	No record.	0.3	0.3	0.24
6	April 23rd, 1895 :— (a.) Same as (a), Experiment I. - (b.) Same as (b), Experiment I. -	-	-	-	-	-	-	-	0.1	0.1	No record.	0.1	0.2	0.12
7	April 24th, 1895 :— (a.) Same as (a), Experiment I. - (b.) Same as (b), Experiment I. -	-	-	-	-	-	-	-	0.0 0.0	0.1 0.1	0.1 0.1	0.2 0.1	0.2 0.1	0.12 0.08
8	April 27th, 1895 :— (a.) Same as (a), Experiment I. - (b.) Same as (b), Experiment I. -	-	-	-	-	-	-	-	0.0	0.1	No record.	0.2	0.2	0.14
9	April 28th, 1895 :— (a.) Same as (a), Experiment I. -	-	-	-	-	-	-	-	0.0	0.1	0.1	0.1	0.2	0.10
10	May 24th, 1895 :— (a.) Same as (a), Experiment I. - (b.) Same as (b), Experiment I. -	-	-	-	-	-	-	-	0.2	0.2	0.3	0.3	0.4	0.28
11	May 28th, 1895 :— (a.) Same as (a), Experiment I., but Keighley post (b.) Same as (b), Experiment I., "	-	-	-	-	-	-	-	0.1 0.2	0.3 0.4	0.5 0.6	0.6 0.6	0.7 0.7	0.44 0.50
12	June 9th, 1895 :— (a.) Same as (a), Experiment I., but Benthams post	-	-	-	-	-	-	-	0.2	0.4	0.5	0.6	0.7	0.28
13	June 10th, 1895 :— (a.) Same as (a), Experiment I., "	-	-	-	-	-	-	-	0.1	0.3	0.3	0.4	0.5	0.32
14	June 15th, 1895 :— (a.) Same as (a), Experiment I. - (b.) Same as (b), Experiment I. -	-	-	-	-	-	-	-	0.2	0.6	0.7	0.7	0.7	0.60
15	June 19th, 1895 :— (a.) Same as (a), Experiment I., but Sheffield post (b.) Same as (b), Experiment I. -	-	-	-	-	-	-	-	0.1	0.4	No record.	0.4	0.5	0.4

TABLE CXLVI.—continued.

Experiment.	Description of the Experiment.	Tested after	Acidity :—		Action on Lead (Results stated as Parts per 100,000).				
			Reaction with Lacmoid.	In Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.
16	June 28th, 1896 :— (a.) Same as (a), Experiment I., but Bradford peat (b.) Same as (b), Experiment I.	Days.	Acid very distinct. "	0.73 1.30	1.0	1.6	1.6	1.8	1.98
		(a.) Same day (b.) 25 days			1.3	2.0	2.3	2.4	2.0
17	April 11th, 1896 :— (a.) 100 grms. Settle peat in double muslin filter. 1,000 c.c. distilled water filtered through very slowly. The acid filtrate ( $=0.24$ c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ per 100 c.c.) was neutralised with $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ and tested for plumbo-solvency. (b.) Some of the filtrate (neutralised) kept in partially filled and stoppered bottle for some time.	(a.) Same day (b.) 16 days	Acid very faint.	0.18	0.0	0.0	0.0	0.0	0.0
		(a.) Same day (b.) 15 days			0.0	0.0	0.0	0.0	0.0
18	April 14th, 1896 :— (a.) 100 grms. Settle peat in double muslin filter. 1,000 c.c. distilled water filtered through very slowly. The acid filtrate ( $=0.24$ c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ per 100 c.c.) was neutralised with $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ and tested for plumbo-solvency. (b.) Some of the filtrate (neutralised) kept in partially filled and stoppered bottle for some time.	(a.) Same day (b.) 15 days	Acid very faint.	0.1	0.0	0.0	0.0	0.0	0.0
		(a.) Same day (b.) 14			0.0	0.1	0.2	0.2	0.14
19	April 17th, 1896 :— (a.) 100 grms. Settle peat in double muslin filter. 1,000 c.c. distilled water filtered through very slowly. Filtrate tested for acidity and plumbo-solvency.	(a.) Same day (b.) 14	Acid distinct	0.30	0.0	0.1	0.2	0.2	0.14
		(a.) Same day (b.) 14			0.0	0.1	0.2	0.2	0.14

	(b.) Some of the filtrate kept in completely filled and stoppered bottle or some time.	(b.) 13 days	"	0.36	0.0	0.1	0.1	0.1	0.08
20	April 19th, 1895 :— (a.) Same as (a), Experiment 19 - (b.) Same as (b), Experiment 19 -	- (a.) Same day (b.) 11 days	Acid distinct "	0.36 0.43	0.0 0.0	0.2 0.1	0.3 0.2	0.3 0.2	0.20 0.13
21	April 20th, 1895 :— (a.) Same as (a), Experiment 19 - (b.) Same as (b), Experiment 19 -	- (a.) Same day (b.) 13 days	Acid distinct Acid very distinct.	0.36 0.66	0.0 0.2	0.1 0.4	0.3 0.5	0.3 0.5	0.18 0.40
22	May 17th, 1895 :— (a.) Same as (a), Experiment 19 - (b.) Same as (b), Experiment 19 -	- (a.) Same day (b.) 10 days	Acid very distinct. "	0.48 0.72	0.2 0.2	0.4 0.4	0.5 0.6	0.5 0.6	0.43 0.46
23	May 18th, 1895 :— (a.) Same as (a), Experiment 19 - (b.) Same as (b), Experiment 19 -	- (a.) Same day (b.) 11 days	Acid very distinct. "	0.48 0.60	0.1 0.2	0.3 0.3	0.3 0.4	0.4 0.5	0.28 0.36
24	May 23rd, 1895 :— (a.) Same as (a), Experiment 19 - (b.) Same as (b), Experiment 19 -	- (a.) Same day (b.) 12 days	Acid very distinct. "	0.48 0.73	0.2 0.2	0.3 0.3	0.3 0.4	0.4 0.5	0.30 0.38
25	May 27th, 1895 :— (a.) Same as (a), Experiment 19 - (b.) Same as (b), Experiment 19 -	- (a.) Same day (b.) 11 days	Acid very distinct. "	0.48 1.44	0.2 0.6	0.6 1.2	0.8 1.3	0.8 1.3	0.63 1.12
26	June 8th, 1895 :— (a.) Same as (a), Experiment 19, but Benthams peat - (b.) Same as (b), Experiment 19 -	- (a.) Same day (b.) 20 days	Acid very distinct. Acid very distinct. "	0.48 1.20	0.2 0.7	0.4 1.1	0.6 1.2	0.7 1.2	0.5 1.08
27	April 18th, 1895 :— (a.) 100 grms. Settle peat in double muslin filter. 1,000 c.c. distilled water filtered through very slowly.	(a.) Same day	The water was neutralised.	0.0	0.0	0.0	0.0	0.0	0.00

\* This must not be regarded as a return to acidity, as this amount (0.18 c.c.  $\frac{10}{10}$   $\text{Na}_2\text{CO}_3$  per 100 c.c.) would be required to give a decided pink colour (with phenol-phthalein as an indicator) to an acid water shortly after its neutralisation.

TABLE CXLVI.—continued.

Experiment.	Description of the Experiment.	Tested after	Acidity :—		Action on Lead (Results stated as Parts per 100,000).				
			Reaction with Lacmoid.	In Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c. Average.
27— cont.	The acid filtrate ( $=0.36$ c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ per 100 c.c.) was neutralised with $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ and tested for plumbosolvency. (b.) Some of the filtrate (neutralised) kept in completely filled and stoppered bottle for some time.	Days. (b.) 11 days	Acid faint	0.24			Traces.		
28	April 20th, 1895 :— (a.) Same as (a), Experiment 27 The acidity of filtrate before neutralisation was $=0.38$ c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ per 100 c.c. of the liquid. (b.) Same as (b), Experiment 27	(a.) Same day (b.) 11 days	The water was neutralised. Acid faint	0.24	0.0	0.0	0.0	0.0	0.00
29	May 3rd, 1895 :— (a.) Same as (a), Experiment 27 The acidity of the filtrate before neutralisation was $=0.80$ c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ per 100 c.c. of the liquid. (b.) Same as (b), Experiment 27	(a.) Same day (b.) 12 days	The water was neutralised. Acid very distinct.	0.90	0.0	0.0	0.1	0.1	0.06
30	May 21st, 1895 :— (a.) Same as (a), Experiment 27 The acidity of the filtrate before neutralisation was $=0.48$ c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ per 100 c.c. of the liquid. (b.) Same as (b), Experiment 27	(a.) Same day (b.) 11 days	The water was neutralised. Acid faint	0.24	0.0	0.0	0.0	0.0	0.00

The samples of peat were obtained from moorland near Settle and Bentham; and from Keighley, Sheffield, and Bradford gathering grounds.

The first sixteen experiments show the effect, as regards acidity and plumbo-solvency, of filtering neutral distilled water through peat. They also show the result of keeping the filtrate thus obtained, for varying periods of time, in partially filled and stoppered bottles. Sometimes storing the peat filtrate resulted in an increase of the initial acidity and plumbo-solvent ability of the liquid; but usually the filtrate, examined in the fresh condition (same day) and also some considerable time afterwards, yielded approximately the same results.

Experiments 19 to 26 deal with the same question, but the peat filtrate was stored in *completely* filled and stoppered instead of in *partially* filled and stoppered bottles. Here storage more uniformly and decidedly increased the initial acidity and plumbo-solvency of the artificial peaty water.

In Experiments 17 and 18, the acid peat filtrates were first neutralised; subsequently they were twice tested for plumbo-solvency, *i.e.*, immediately and after storing for some time in partially filled and stoppered bottles. In both cases, the liquid showed no solvent action on lead; and in the case of the stored filtrate there was hardly any appreciable return of acidity. In Experiments 27 to 30, the peat filtrate, after neutralisation, was stored in *completely* filled and stoppered bottles. As in Experiments 17 and 18, the neutralised artificial peaty water did not dissolve lead; but the liquid, after being kept for some time, showed a slight tendency to re-develop acid and plumbo-solvent properties. With the exception, however, of Experiment 29, in which there seemed to be a decided production of acid, the neutralised waters may be said to have remained practically neutral and free from plumbo-solvent ability, when stored in completely filled and stoppered bottles.

#### *Summary (under Section III. A.).*

The following is a brief summary of the foregoing tables:—

A relatively small quantity of peat can render acid and plumbo-solvent a large bulk of neutral non-plumbo-solvent water under the following conditions of experiment when the—

- (a.) Peat is left in contact with a large bulk of stagnant water;
- (b.) Water is intermittently filtered through peat;
- (c.) Water is continuously passed through peat saturated with water.

Peat alone confers practically as much acidity and plumbo-solvency on neutral water as peat mixed with sulphide of iron, powdered shale, or iron ore. But peat mixed with iron pyrites is apt to render water more acid and plumbo-solvent in character than peat by itself.

Peat rich in iron would not seem to impart to water filtered through it acidity and plumbo-solvency to any greater extent than peat containing little or no iron.

Heating peat to 100° C., or keeping it for a long period in a moist chamber, seemingly increases its ability of conferring on water filtered through it acid and plumbo-solvent properties. But further experiments in this connection are desirable.

Artificial peat filtrates kept under the following conditions yield, as regards acidity and plumbo-solvency, the following results:—

Not neutralised	{	Kept in partially filled and stop- pered bottles.	}	Initial acidity and plumbo-solvency but slightly affected.
		Kept in complete- ly filled and stoppered bottles.		
				Initial acidity and plumbo-solvency seemingly slightly increased.



Neutralised	Kept in partially filled and stoppered bottles.	Results, as regards re-development of acidity and plumbo-solvency, practically negative.
	Kept in completely filled and stoppered bottles.	Results usually negative, or acidity and plumbo-solvency barely appreciable.

### B.—BACTERIOLOGICAL EXPERIMENTS.

As far back as 1887,\* Mr. Power raised the question "whether the inscrutable behaviour of soft moorland waters in regard of their plumbo-solvent ability may not be related to the agency, direct or indirect, of low forms of organic life," and "whether chemistry, which by itself has failed to afford satisfactory explanation of the plumbo-solvency of moorland water, may not get advantage by association of biology in the problem." In 1890, when the sanction of the Board was obtained to an inquiry into the subject of lead poisoning by moorland waters, it was determined that bacteriological, as well as chemical, investigations should be carried out, with a view to learning the conditions under which moorland waters acquire their power of dissolving lead. The general outcome of these researches was reported on by Mr. Power† in the Annual Report of the Medical Officer of the Local Government Board for 1893-94. The following is a detailed account of the work carried out in this connection :—

Already, in Volume I. of the complete report, an account has been given of the more general side of the question. Thus, tables dealing with the number and character of the bacteria to be found in peat and in peaty waters have been fully considered and need not again be alluded to here, unless in a cursory manner. In this volume the more specialised side of the problem will be dealt with, especially that part which seeks to throw fresh light on the question of the antecedent cause of the acidity of moorland waters.

A foundation for the work was obtained by the observations made in 1892 at Burnmoor, namely, that moist peat soil invariably has an acid reaction. These observations were subsequently confirmed in connection with the surveys of numerous other moorland gathering grounds in Lancashire and Yorkshire. The observed fact of the acidity of the peat itself, coupled with the circumstance that acid moorland waters kept under laboratory conditions failed to increase their acidity (or, if previously neutralised, to acquire fresh acid, and that such acid waters were always derived from the peat, led to a prolonged study of the bacteriology of peat soil and the effect, as regards acidity, of the addition of peat microbes to sterile neutral peat decoction. In brief, at the period referred to, the provisional conclusion, or rather working hypothesis, was attained, namely, that the antecedent cause of the acidity of moorland waters was to be sought for in the peat itself, and that neither the rain falling on the peat nor the water after it had left the peat could be held directly responsible for the production of acid. In this view of the case, the rain is regarded merely as the agent necessary, but not directly responsible, for the production of acid by processes occurring in the substance of the peat, and as the vehicle by means of which acid

\* Supplement by the Medical Officer to the 17th Annual Report of the Local Government Board, 1888.

† Lead Poisoning by Moorland Waters, 1893-94.

substances, previously manufactured in the peat, are washed into streams supplying or contributory to the supply of the waterworks.

It has already been shown that acid moorland waters, whether kept in partially filled and not stoppered, or in completely filled and stoppered bottles, never show an increase of their initial acidity, and, further, that neutralisation with sodium carbonate and subsequent retention of the samples, under different conditions of exposure to air, in no instance results in any appreciable re-development of acidity. Acid moorland waters, kept in stoppered bottles, with and without the inhibition of bacterial growth by means of alcohol, show when tested, a similar degree of acidity; but if the nutritive power of a peaty water is increased by the addition of sterile peat decoction, then a further development of acidity may be observed if to the mixture of peat decoction and water no alcohol be added previous to such storage. These results are shown in Tables CXLVII. and CXLVIII. They might have been included at an earlier stage of the report; but as they involved questions of bacterial growth, it was deemed advisable to include them in the bacteriological section of the report.

TABLE CXLVII.

Showing the RESULT as regards ACIDITY of keeping certain ACID MOORLAND WATERS in Stoppered Bottles, with and without the Inhibition of Bacterial Growth with ALCOHOL.

Experiment.	Description of the Experiment.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neu- tralise 100 c.c. of the Water.
1	July 23rd, tested July 30th, 1894:— (a.) 50 c.c. Shipley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 1.2 (b.) 1.2
2	July 24th, tested August 6th, 1894:— (a.) 50 c.c. Mossley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 0.6 (b.) 0.6
3	July 30th, tested August 13th, 1894:— (a.) 50 cc. Shipley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 1.2 (b.) 1.2
4	July 31st, tested August 13th, 1894:— (a.) 50 c.c. Shipley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 0.6 (b.) 0.6
5	August 6th, tested August 18th, 1894:— (a.) 50 c.c. Shipley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 1.2 (b.) 1.2
6	August 7th, tested August 18th, 1894:— (a.) 50 c.c. Mossley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 0.6 (b.) 0.6
7	August 13th, tested August 23rd, 1894:— (a.) 50 c.c. Shipley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 1.2 (b.) 1.2
8	August 14th, tested August 23rd, 1894:— (a.) 50 c.c. Mossley water + 0 in stoppered bottle with air space - (b.) " " " " + 5 c.c. absolute alcohol " " -	(a.) 0.6 (b.) 0.6

It will be noted that Shipley and Mossley waters, kept in stoppered bottles (a) with and (b) without the inhibition of bacterial growth with alcohol, gave on testing the same results as regards acidity under (a) and (b) conditions.

TABLE CXLVIII.

Showing the **EFFECT** (as regards **ACIDITY**) produced by increasing the nutritive power of **SETTLE PEAT POOL WATER** with **PEAT DECOCTION**.

[The control experiment was obtained by inhibiting the growth of microbes with alcohol.]

Experiment.	Description of Experiment.				Date of Experiment.	A, B, tested for Acidity.	c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise.		Increase of Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.
							A.	B.	
1	50 c.c. Settle peat pool water + 10 c.c. sterile peat decoction.	A + 5 c.c. alcohol	B + no alcohol	in stoppered bottle with a n air space.	1894. Jan. 29	1894. Feb. 10	0.84	1.80	0.96
2	" " " "	"	"	"	Feb. 14	" 24	0.48	0.54	0.12
3	" " " "	"	"	"	" 24	" 28	0.42	0.84	0.84
4	" " " "	"	"	"	" 28	Mar. 6	0.48	1.56	2.16
5	" " " "	"	"	"	Mar. 2	" 8	0.48	1.00	1.04
6	" " " "	"	"	"	" 9	" 18	0.30	0.30	0.00
7	" " " "	"	"	"	" 19	" 31	0.36	0.36	0.00
8	" " " "	"	"	"	June 5	June 9	0.30	0.72	0.84

A distinct cloudiness always developed in B, but never in A (control experiments). Immediately before testing the acidity, 5 c.c. alcohol were added to B, so that B might fairly be compared with A.

The results show that increasing the nutritive power of Settle Peat Pool water, by the addition to the water of sterile peat decoction, resulted usually in an increase of the amount of acid in the water. This fact was judged by comparison with experiments similar in all respects, save that, to inhibit bacterial growth, alcohol was added to the water. The results seemed to indicate that biological considerations were possibly involved in the production of acid, and, further, that the reason why moorland waters failed, on keeping, to increase their initial acidity, was due to their having "become divorced from the peat."\* As Mr. Power explained, in his 1893 report, the several lines of work interlaced at various points, and many of them were pursued concurrently. The following sequence of description does not therefore necessarily imply chronological sequence of procedure. It is convenient in the first case to consider two tables (CXLIX. and CL.) which deal with the effect, as regards acidity, of adding, in minute amount, moorland waters to sterile peat decoction.

\* See page 343 of Mr. Power's report, "Lead Poisoning by Moorland Waters," report of the Medical Officer, Local Government Board, 1893-94.

TABLE CXLIX.

Showing the RESULT, as regards ACIDITY, of INOCULATING STERILE PEAT DECOCTION with MINIMAL QUANTITIES of MOORLAND WATERS.

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.
1	July 30th, tested August 7th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.09 c.c. Shipley water - (c.) " " " " " " " (d.) " " " " " " "	Neutral ? Trace acid " "	1.2 3.6 3.6 3.6
2	July 31st, tested August 7th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.09 c.c. Mossley water - (c.) " " " " " " " (d.) " " " " " " "	Neutral ? Trace acid " "	1.2 2.4 3.6 2.4
3	August 6th, tested August 15th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.09 c.c. Shipley water - (c.) " " " " " " " (d.) " " " " " " "	Neutral " " "	1.2 3.6 3.6 3.6
4	August 7th, tested August 14th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.09 c.c. Mossley water - (c.) " " " " " " "	Neutral " "	1.2 3.6 3.6
5	August 15th, tested August 18th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.1 c.c. Shipley water - (c.) " " " " " " "	Neutral " "	1.2 2.4 2.4
6	August 14th, tested August 18th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.1 c.c. Mossley water - (c.) " " " " " " "	Neutral " "	1.2 1.2 1.2
7	August 21st, tested August 28th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.1 c.c. Shipley water - (c.) " " " " " " "	Neutral Distinctly acid. "	1.2 4.8 4.8
8	August 22nd, tested August 28th, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.1 c.c. Mossley water - (c.) " " " " " " "	Neutral Distinctly acid. "	1.2 4.8 4.8
9	August 25th, tested September 1st, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.1 c.c. Fletcher's dyke water " (feeder "Mytholmroyd Reservoir. Morley water supply).	Neutral Distinctly acid.	1.2 4.8
10	August 25th, tested September 1st, 1894:— (a.) 10 c.c. sterile peat decoction+0 in test tube. Control experiment. (b.) " " " +0.1 c.c. Jack Clough water " (feeder "Mytholmroyd Reservoir. Morley water supply).	Neutral Distinctly acid.	1.2 4.8

TABLE CXLIX.—continued.

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. <sup>10</sup> Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Liquid.
11	August 28th, tested September 1st, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Within's Stream (feeder Mytholmroyd Reservoir. Morley water supply).	Neutral Distinctly acid.	1.2 4.8
12	August 28th, tested September 1st, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Mytholmroyd Reservoir. Morley water supply.	Neutral Distinctly acid.	1.2 4.8
13	August 28th, tested September 4th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Shipley water - (c.) " " " " " " " "	Neutral Distinctly acid. "	1.2 4.8 4.8
14	August 28th, tested September 4th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Mossley water - (c.) " " " " " " " "	Neutral Distinctly acid.	1.2 4.8
15	September 11th, tested September 24th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Shipley water - (c.) " " " " " " " "	Neutral " ? Trace acid	1.2 1.2 2.4
16	September 11th, tested September 24th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Mossley water - (c.) " " " " " " " "	Neutral Acid "	1.2 2.4 3.6
17	November 13th, tested November 26th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Shipley water - (c.) " " " " " " " "	Neutral Acid "	1.2 2.4 3.4
18	November 13th, tested November 26th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Mossley water - (c.) " " " " " " " "	Neutral Acid "	1.2 2.4 2.4
19	November 20th, tested November 26th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Shipley water -	Neutral Acid	1.2 3.6
20	November 20th, tested November 28th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Mossley water -	Neutral Acid	1.2 2.4
21	November 24th, tested December 15th, 1894:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Dunford Bridge Reservoir water. Dewsbury water supply. (c.) " " " " " " " "	Neutral Distinctly acid. "	1.2 6.0 6.0
22	November 26th, 1894, tested January 31st, 1895:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Shipley water - (c.) " " " " " " " "	Neutral " "	1.2 1.2 1.2
23	November 28th, 1894, tested January 31st, 1895:— (a.) 10 c.c. sterile peat decoction + 0 in test tube. Control experiment. (b.) " " " " + 0.1 c.c. Mossley water - (c.) " " " " " " " "	Neutral " "	1.2 1.2 1.2

It is to be noted that the addition of moorland waters, always in minute amount, and obtained from different gathering grounds, to sterile peat decoction not uncommonly led to the production of acid. These results led to the inference that moorland waters are apt to contain bacteria, probably derived from the peat, capable, when brought in relation with sterile peat decoction, of generating acid therein.

TABLE CL.

Showing the RESULT, as regards ACIDITY, of INOCULATING STERILE PEAT DECOCTION containing 1 per cent. GLUCOSE with MINIMAL QUANTITIES of a MOORLAND WATER.

Experiment.	Description of the Experiment.	Reaction with Indmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ needed to neutralise 100 c.c. of the Liquid.
1	January 21st, tested January 29th, 1895 :— (a.) 10 c.c. sterile peat decoction, containing 1 per cent. glucose + 0 in test tube. Control experiment. (b.) 10 c.c. sterile peat decoction, containing 1 per cent. glucose + 0·1 c.c. Shipley water. (c.) 10 c.c. sterile peat decoction, containing 1 per cent. glucose + 0·1 c.c. Shipley water.	Neutral Acid Acid	1·2 2·4 2·4
2	January 29th, tested February 4th, 1895 :— (a.) 10 c.c. sterile peat decoction, containing 1 per cent. glucose + 0 in test tube. Control experiment. (b.) 10 c.c. sterile peat decoction, containing 1 per cent. glucose + 0·1 c.c. Shipley water. (c.) 10 c.c. sterile peat decoction, containing 1 per cent. glucose + 0·1 c.c. Shipley water.	Neutral Neutral Acid	2·4 2·4 4·8
3	February 5th, tested February 12th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " (b), " " " " " " " " " " " "	Neutral Acid	2·4 8·4
4	February 12th, tested February 19th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " (b), " " " " " " " " " " " "	Neutral Acid	2·4 7·2
5	February 19th, tested March 6th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " (b), " " " " " " " " " " " "	Neutral Acid	2·4 6·0
6	March 6th, tested March 14th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " (b), " " " " " " " " " " " "	Neutral Acid	2·4 10·8

A similar result was obtained when peat decoction containing glucose was used as a medium ; but here the results are not so significant as when peat decoction alone was employed for cultural purposes.

Later on in the investigation the experiments set forth in Table CXLIX. were repeated, but a larger bulk of the peat decoction was used for cultural purposes, so as to admit of the liquid being tested for plumbo-solvency as well as for acidity. The results are shown in the table (Table CLI.) following.

TABLE CLI.

Showing the RESULT, as regards ACIDITY and PLUMBO-SOLVENT ABILITY, of inoculating STERILE PEAT DECOCTION with MINIMAL QUANTITIES of CERTAIN MOORLAND WATERS.

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on Lead (Results stated as Parts per 100,000). The action on Lead was tested by means of upward filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
1A.	500 c.c. sterile peat decoction + 0. <i>Control experiment.</i> March 11th, 1896, tested March 20th, 1896.	Neutral	0.4	0.0	0.0	0.0	0.0	0.0	0.00
1B.	500 c.c. sterile peat decoction + 0.85 c.c. water from acid peaty feeder to Langden Brook (Preston Waterworks). March 11th, tested March 20th, 1896.	V. ft. acid	1.2			Traces.			
1C.	500 c.c. sterile peat decoction + 0.9 c.c. water from Langden Brook (Preston Waterworks). March 11th, tested March 20th, 1896.	V. ft. acid	1.0	0.3	0.3	0.3	0.3	0.3	0.30
1D.	500 c.c. sterile peat decoction + 1 c.c. water from Stony Clough, Whitendale Valley (Blackburn Waterworks). March 13th, tested March 20th, 1896.	V. ft. acid	1.2			Traces.			
2A.	500 c.c. sterile peat decoction + 0. <i>Control experiment.</i> March 20th, tested April 4th, 1896.	Neutral	0.6	0.0	0.0	0.0	0.0	0.0	0.00
2B.	500 c.c. sterile peat decoction + 0.85 c.c. water from Poaka Beck Reservoir (Barrow-in-Furness Waterworks). March 20th, tested April 4th, 1896.	† Neutral	0.9	0.25	0.25	0.25	0.25	0.25	0.25
2C.	500 c.c. sterile peat decoction + 0.85 c.c. water from inlet to Swinden Reservoir (Swinden Brook) Burnley Waterworks. March 27th, tested April 4th, 1896.	† Neutral	0.9			Traces.			

TABLE CLI.—*continued.*

Experiment.	Description of the Experiment.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Action on lead (Results stated as Parts per 100,000). The action on Lead was tested by upward Filtration through 50 c.c. washed Lead Shot at the rate of 3 mins. per 50 c.c.					
				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.
2D.	500 c.c. sterile peat decoction + 0.9 c.c. water from Cant Clough Beck, Burnley Waterworks. March 27th, tested April 4th, 1896.	? Trace acid.	1.5	0.4	0.4	0.4	0.4	0.4	0.40
3A.	500 c.c. sterile peat decoction + 0. <i>Control experiment.</i> March 31st, tested April 11th, 1896.	Neutral	0.6	0.0	0.0	0.0	0.0	0.0	0.00
3B.	500 c.c. sterile peat decoction + 0.85 c.c. water from Sheephouse Clough Reservoir (Bacup Waterworks). March 31st, tested April 11th, 1896.	? Neutral	0.9			? Traces.			
3C.	500 c.c. sterile peat decoction + 0.9 c.c. water from inlet to Sheephouse Clough Reservoir (Bacup Waterworks). March 31st, tested April 11th, 1896.	V. ft. acid	1.2			Traces.			

The results were, on the whole, confirmatory of those detailed in Table CXLIX.; but the acidity produced was usually slight in amount, and the solvent action on lead by no means well marked. Still, there could be no question that the peat decoction, as the result of its inoculation with minimal quantities of moorland water, developed occasionally appreciable acid and plumbo-solvent properties.

Next to be considered is a number of tables which show the results, as regards acidity, of inoculating with a mixture of peat microbes sterile peat decoction alone, peat decoction *plus* peptone and salt, peat decoction *plus* cane sugar, and peat decoction *plus* glucose. The most important of these experiments were the series in which peat decoction unmixed with any other ingredient was used for cultural purposes. It is convenient to consider these in the first place.



TABLE CLII.

Showing the RESULTS of INOCULATION of STERILE PEAT DECOCTION with a MIXTURE of PEAT MICRO-ORGANISMS. 34 experiments with 28 samples of peat soil, and 50 inoculations of sterile peat decoction.

[The samples of peat soil were obtained from the Bentham (Burnmoor) gathering grounds. (Page 1, Vol. I.)]

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil With Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 1.</i> 4 tubes containing sterile peat decoction inoculated each with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. September 30th, 1893.	10.502 grms. soil in 500 c.c. sterile water.	96 germs in 0.24 c.c.	Per cent. 71	Tested 14th and 19th October 1893, with negative results. Lactmold, litmus, phenol - phthalein used as indicators.	a = 0.0 b = 0.0 c = 0.0 d = 0.0
<i>Experiment No. 2.</i> 4 tubes (a, b, c, d) containing sterile peat decoction inoculated each with 0.056 c.c. soil mixture. Incubated 30° C. 1 control. September 30th, 1893.	3.61 grms. soil in 500 c.c. sterile water.	60 germs in 0.066 c.c.	70	14th October, 1893. a. and b. negative results with lactmold and litmus. 19th October 1893, c and d negative results with lactmold and litmus, 5 c.c. titrated with $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ and phenol-phthalein. Control, 0.24 c.c.; sample c, 0.3 c.c.; sample d, 0.42 c.c.	a = 0.0 b = 0.0 c = 1.2 d = 3.6
<i>Experiment No. 3.</i> 2 tubes (a, b) containing sterile peat decoction inoculated each with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. October 5th, 1893.	8.902 grms. soil in 500 c.c. sterile water.	159 germs in 0.04 c.c.	81	20th October 1893. Sample a negative result. Sample b titrated with $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ and lactmold. Control, 5 c.c., required 0.24 c.c., and sample b, 0.36 c.c. $\frac{10}{10}$ alkali.	a = 0.0 b = 2.4
<i>Experiment No. 4.</i> 2 tubes (a, b) containing sterile peat decoction inoculated each with 0.056 c.c. soil mixture. Incubated 30° C. 1 control. October 5th, 1893.	6.362 grms. soil in 500 c.c. sterile water.	177 germs in 0.056 c.c.	88	20th October 1893. a and b negative results with litmus and lactmold. With phenol-phthalein a negative result, b required 0.18 c.c. $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ as against 0.12 c.c.; control, 5 c.c. in each case.	a = 0.0 b = 1.2

TABLE CLII.—continued.

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid 1 c.c. = 0.0033 Grams $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 5.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. October 11th, 1893.	6.068 grms. soil in 500 c.c. sterile water.	80 germs in 0.04 c.c.	Per cent. 81	20th October 1893. Lacomoid and litmus negative results. Titrated with phenol-phthalein, 5 c.c., control 0.18 c.c., sample a, 0.24 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 1.2$
<i>Experiment No. 6.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.066 c.c. soil mixture. Incubated 30° C. 1 control. October 11th, 1893.	5.42 grms. soil in 500 c.c. sterile water.	63 germs in 0.066 c.c.	81	20th October 1893. Negative results with lacomoid, litmus, and phenol-phthalein.	$a = 0.0$
<i>Experiment No. 7.</i> 2 tubes (a, b) containing sterile peat decoction inoculated each with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. October 18th, 1893.	6.766 grms. soil in 500 c.c. sterile water.	86 germs in 0.04 c.c.	79	26th October 1893. Sample a, negative results. Sample b, 5 c.c. with phenol-phthalein 0.24 c.c. as against 0.06 c.c. control and with lacomoid 0.12 as against 0.0 c.c. control $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 0.0$ $b = 3.0$
<i>Experiment No. 8.</i> 2 tubes (a, b) containing sterile peat decoction inoculated each with 0.056 c.c. soil mixture. Incubated 30° C. 1 control. October 18th, 1893.	5.51 grms. soil in 500 c.c. sterile water.	54 germs in 0.056 c.c.	75	26th October 1893. 5 c.c. with phenol-phthalein, sample a, 0.12; sample b, 0.18; control, 0.06 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacomoid, sample a, 0.0; sample b, 0.06; control 0.0 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 1.2$ $b = 2.7$
<i>Experiment No. 9.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. October 18th, 1893. (A different peat decoction to that used in Experiment 7.)	6.766 grms. soil in 500 c.c. sterile water.	88 germs in 0.04 c.c.	79	23rd October 1893. 5 c.c. with phenol-phthalein, sample a, 0.24; control, 0.06 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . 4 c.c. with lacomoid, sample a, 0.13; control, 0.0 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 4.0$
<i>Experiment No. 10.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.066 c.c. soil mixture. Incubated 30° C. 1 control. October 18th, 1893. (A different peat decoction to that used in Experiment No. 8.)	5.51 grms. soil in 500 c.c. sterile water.	54 germs in 0.066 c.c.	75	23rd October 1893. 5 c.c. with phenol-phthalein, sample a, 0.12; control, 0.06 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacomoid; sample a, 0.12; control, 0.0 c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 1.8$

TABLE CLII.—*continued.*

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{x}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 11.</i> 2 tubes (a, b) containing sterile peat decoction inoculated each with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. October 25th, 1893.	4.934 grms. soil in 500 c.c. sterile water.	50 germs in 0.04 c.c.	Per cent. 75	31st October 1893. Negative results with phenol-phthalein and lacmoid as indicators.	a = 0.0 b = 0.0
<i>Experiment No. 12.</i> 2 tubes (a, b) containing sterile peat decoction inoculated each with 0.056 c.c. soil mixture. Incubated 30° C. 1 control. October 25th, 1893.	6.745 grms. soil in 500 c.c. sterile water.	783 germs in 0.056 c.c.	74	4th November 1893. Negative results with phenol-phthalein and lacmoid as indicators.	a = 0.0 b = 0.0
<i>Experiment No. 13.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 21° C. 1 control. November 1st, 1893.	6.975 grms. soil in 500 c.c. sterile water.	246 germs in 0.04 c.c.	87	6th November 1893. Negative results with lacmoid; 5 c.c. with phenol-phthalein; sample a, 1.02 c.c.; control, 0.66 c.c. $\frac{x}{10}$ $\text{Na}_2\text{CO}_3$ .	a = 7.2
<i>Experiment No. 14.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 21° C. 1 control. November 1st, 1893.	11.159 grms. soil in 500 c.c. sterile water.	144 germs in 0.035 c.c.	80	6th November 1893. Negative results with lacmoid; 5 c.c. with phenol-phthalein; sample a, 1.2 c.c.; control, 0.66 c.c. $\frac{x}{10}$ $\text{Na}_2\text{CO}_3$ .	a = 11.2
<i>Experiment No. 15.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 1st, 1893. (A different peat decoction to that used in Experiment 13.)	6.975 grms. soil in 500 c.c. sterile water.	246 germs in 0.04 c.c.	87	18th November 1893. Negative results with lacmoid and phenol-phthalein as indicators.	a = 0.0
<i>Experiment No. 16.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 1st, 1893. (A different peat decoction to that used in Experiment 14.)	11.159 grms. soil in 500 c.c. sterile water.	144 germs in 0.035 c.c.	80	18th November 1893. Negative result with lacmoid; 4 c.c. with phenol-phthalein; sample a, 0.16 c.c.; control, 0.12 c.c. $\frac{x}{10}$ $\text{Na}_2\text{CO}_3$ .	a = 1.5

TABLE CLII.—continued.

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0083 Grm. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 17.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 8th, 1893.	12.765 grms. soil in 500 c.c. sterile water.	141 germs in 0.04 c.c.	Per cent. 88	23rd November 1893. 5 c.c. with phenolphthalein and with lacmoid; sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 1.2$
<i>Experiment No. 18.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 8th, 1893.	4.233 grms. soil in 500 c.c. sterile water.	7 germs in 0.035 c.c.	82	November 24th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, sample a, 0.18; control, 0.0 $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.4$
<i>Experiment No. 19.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 15th, 1893.	8.026 grms. soil in 500 c.c. sterile water.	103 germs in 0.035 c.c.	74	November 24th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, sample a, 0.18 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.4$
* <i>Experiment No. 20.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 15th, 1893.	5.292 grms. soil in 500 c.c. sterile water.	31 germs in 0.04 c.c.	91	November 24th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, sample a, 0.18 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.4$
<i>Experiment No. 31.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 22nd, 1893.	6.446 grms. soil in 500 c.c. sterile water.	71 germs in 0.04 c.c.	71	December 9th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.08 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.1$

TABLE CLII.—continued.

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculation.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. $\frac{N}{10}$ c.c. = 0.0088 Grms. $\text{Na}_2\text{CO}_3$
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
* Experiment No. 22. 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 20° C. 1 control. November 22nd, 1893.	4.297 grms. soil in 500 c.c. sterile water.	18 germs in 0.035 c.c.	Per cent. 67	December 9th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.7$
Experiment No. 23. 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 29th, 1893.	9.18 grms. soil in 500 c.c. sterile water.	77 germs in 0.04 c.c.	82	December 18th, 1893. Negative results with lacmoid and phenol-phthalein as indicators.	$a = 0.0$
* Experiment No. 24. 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 29th, 1893.	4.04 grms. soil in 500 c.c. sterile water.	9 germs in 0.035 c.c.	82	December 18th, 1893. Negative results with phenol-phthalein; 2 c.c. with lacmoid, sample a 0.06 c.c. control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 3.0$
Experiment No. 25. 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 6th, 1893.	14.335 grms. soil in 500 c.c. sterile water.	294 germs in 0.04 c.c.	87	December 22nd, 1893. Negative results with phenol-phthalein and lacmoid as indicators.	$a = 0.0$
* Experiment No. 26. 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 6th, 1893.	5.201 grms. soil in 500 c.c. sterile water.	15 germs in 0.035 c.c.	64	December 22nd, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c. control, 0.18 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.18 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 5.7$
Experiment No. 27. 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 13th, 1893.	11.153 grms. soil in 500 c.c. sterile water.	23 germs in 0.04 c.c.	71	January 1st, 1894. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.1$

TABLE CLII.—continued.

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
* <i>Experiment No. 28.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 13th, 1893.	7.024 grms. soil in 500 c.c. sterile water.	6 germs in 0.035 c.c.	Per cent. 74	January 1st, 1894. Negative results with phenol-phthalein; 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 3.0$
<i>Experiment No. 29.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 20th, 1893.	8.142 grms. soil in 500 c.c. sterile water.	23 germs in 0.04 c.c.	87	January 12th, 1894. 5 c.c. with phenol-phthalein, sample a, 0.24 c.c.; control, 0.18 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.1$
* <i>Experiment No. 30.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 20th, 1893.	8.573 grms. soil in 500 c.c. sterile water.	13 germs in 0.035 c.c.	84	January 13th, 1894. 5 c.c. with phenol-phthalein, sample a, 0.24 c.c.; control, 0.18 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2$
<i>Experiment No. 31.</i> 2 tubes (a, b) containing sterile peat decoction inoculated each with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893.	18.937 grms. soil in 500 c.c. sterile water.	56 germs in 0.04 c.c.	82	January 13th, 1894. 5 c.c. with phenol-phthalein, sample a and b, 0.24 c.c.; control, 0.18 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, samples a and b, 0.12 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 3.6$ $b = 3.6$
<i>Experiment No. 32.</i> 3 tubes (a, b, c) containing sterile peat decoction inoculated each with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893. (A different peat decoction to that used in Experiment 31.)				January 13th, 1894. 5 c.c. with phenol-phthalein, sample a and b, 0.12 c.c.; sample c, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, samples a, b, c, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 3.0$ $b = 3.0$ $c = 2.1$

TABLE CLII.—*continued.*

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0033 Grm. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
* <i>Experiment No. 33.</i> 1 tube (a) containing sterile peat decoction inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893.	7.894 grms. soil in 500 c.c. sterile water.	18 germs in 0.035 c.c.	Per cent.	January 13th, 1894. 5 c.c. with phenolphthalein, sample a, 0.36 c.c.; control, 0.18 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.24 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 7.8$
* <i>Experiment No. 34.</i> 2 tubes (a. b) containing sterile peat decoction inoculated each with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893. (A different peat decoction to that used in Experiment 33.)			87	January 13th, 1894. 5 c.c. with phenolphthalein, sample a and b, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; sample b, 0.13 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	$a = 2.1$ $b = 3.6$

\* Samples of peat soil obtained from a little below the surface level. In all the other experiments the samples of soil were taken from the surface.  
Where the different indicators give different amounts of acidity the average is taken.

It will be noted that sterile peat decoction alone (i.e., unmixed with any foreign ingredient), when inoculated with a mixture of peat microbes, not uncommonly developed an acid reaction. 28 samples of peat soil were subjected to experiment. They were all obtained from the Bentham (Burnmoor) gathering grounds. The conditions of experiment are fully explained in the table, and need not be further considered here. Another series of experiments was started in January 1894 and continued until August 1895. These experiments were similar to those recorded in Table CLII.; but the samples of peat were obtained from Settle moorland, and from Shipley, Mossley, Morley, Keighley, and Bradford gathering grounds. 60 experiments in all were carried out; the results are shown in Table CLIII.









**TABLE CLIII.—continued.**

Experiment.	Description of the Experiment.	Description of the Peat Soil Mixture used in the Inoculations.	Reaction with Lacomoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Remarks.
17	August 6th, tested August 13th, 1894 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.09 c.c. peat soil mixture. (b.) " " " " " " " " (c.) " " " " " " " " (d.) " " " " " " " " (e.) " " " " " " " "	19.34 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Ft. acid (c.) " " (d.) " " (e.) " "	(a.) 1.2 (b.) 4.8 (c.) 4.8 (d.) 4.8 (e.) 4.8	In all the experiments lacomoid was used to test the reaction of the peat decoction, and phenol-phthalein was used as an indicator in estimating the amount of the acidity.
18	August 13th, tested August 18th, 1894 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.09 c.c. peat soil mixture. (b.) " " " " " " " " (c.) " " " " " " " " (d.) " " " " " " " " (e.) " " " " " " " "	17.11 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid (c.) " " (d.) " " (e.) " "	(a.) 1.2 (b.) 4.8 (c.) 4.8 (d.) 4.8 (e.) 4.8	
19	August 21st, tested August 28th, 1894 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.09 c.c. peat soil mixture. (b.) " " " " " " " " (c.) " " " " " " " " (d.) " " " " " " " " (e.) " " " " " " " "	2.534 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid (c.) " " (d.) " " (e.) " "	(a.) 1.2 (b.) 3.6 (c.) 3.6 (d.) 3.6 (e.) 3.6	100 germs in 0.09 c.c. peat soil mixture.
20	August 25th, tested August 31st, 1894 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.09 c.c. peat soil mixture. (b.) " " " " " " " " (c.) " " " " " " " " (d.) " " " " " " " " (e.) " " " " " " " "	5.13 grms. Morley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid (c.) " " (d.) " " (e.) " "	(a.) 1.2 (b.) 4.8 (c.) 4.8 (d.) 4.8 (e.) 4.8	73 germs in 0.09 c.c. peat soil mixture.
21	August 29th, tested September 4th, 1894 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.09 c.c. peat soil mixture. (b.) " " " " " " " " (c.) " " " " " " " " (d.) " " " " " " " " (e.) " " " " " " " "	4.925 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid (c.) " " (d.) " " (e.) " "	(a.) 1.2 (b.) 4.8 (c.) 4.8 (d.) 4.8 (e.) 4.8	It is to be noted that in all the experiments only a small amount of peat was added to a considerable bulk of sterile water, and that of this peat soil mixture, only minute quantities were added to the sterile peat decoction.
23	September 4th, tested September 11th, 1894 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.09 c.c. peat soil mixture. (b.) " " " " " " " " (c.) " " " " " " " " (d.) " " " " " " " " (e.) " " " " " " " "	6.105 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid (c.) " " (d.) " " (e.) " "	(a.) 1.2 (b.) 4.8 (c.) 4.8 (d.) 4.8 (e.) 4.8	







TABLE CLIII.—continued.

Experiment.	Description of the Experiment.	Description of the Peat Soil Mixture used in the Inoculations.	Reaction with Lacmoid.	Acidity in Terms of c.c. % Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Liquid.	Remarks.
45	May 18th, tested May 20th, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. (b.) " " " " (c.) " " " "	Control experiment +0·1 c.c. peat soil mixture. " " "	(a.) Neutral (b.) Trace acid. (c.) "	(a.) 2·4 (b.) 3·6 (c.) 4·8	
46	May 21st, tested May 29th, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. (b.) " " " " (c.) " " " " (d.) " " " " (e.) " " " "	Control experiment +0·1 c.c. peat soil mixture. " " " " "	(a.) Neutral (b.) Acid (c.) " (d.) " (e.) "	(a.) 2·4 (b.) 2·4 (c.) 6·0 (d.) 6·0 (e.) 6·0	98 germs in 0·1 c.c. peat soil mixture.
47	May 28th, tested June 5th, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. (b.) " " " " (c.) " " " "	Control experiment +0·1 c.c. peat soil mixture. " " "	(a.) Neutral (b.) " (c.) "	(a.) 2·4 (b.) 2·4 (c.) 2·4	30 germs in 0·1 c.c. peat soil mixture.
48	May 29th, tested June 5th, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. (b.) " " " " (c.) " " " "	Control experiment +0·1 c.c. peat soil mixture. " " "	(a.) Neutral (b.) " (c.) "	(a.) 3·6 (b.) 4·8 (c.) 6·0	96 germs in 0·1 c.c. peat soil mixture.
49	June 5th, tested June 10th, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. (b.) " " " " (c.) " " " " (d.) " " " " (e.) " " " "	Control experiment +0·1 c.c. peat soil mixture. " " " " "	(a.) Neutral (b.) " (c.) " (d.) " (e.) "	(a.) 1·2 (b.) 2·4 (c.) 2·4 (d.) 2·4 (e.) 2·4	





TABLE CLIII.—*continued.*

Experiment.	Description of the Experiment.	Description of the Peat Soil Mixture used in the Inoculations.	Reaction with Læcmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid.	Remarks.
58	August 6th, tested August 24th, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.1 c.c. peat soil mixture. " " " "	10.8 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid -	(a.) 1.2 (b.) 6.0	
59	August 14th, tested August 24th, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.1 c.c. peat soil mixture. " " " "	6.0 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid -	(a.) 1.2 (b.) 6.0	
60	August 27th, tested September 2nd, 1895 :— (a.) 10 c.c. sterile peat decoction in test tube +0. Control experiment +0.1 c.c. peat soil mixture. " " " "	4.3 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) " -	(a.) 1.2 (b.) 6.0	

Experiments with sterile peat decoction, to which one of the following substances had been added, viz., sodium phosphate, calcium phosphate, magnesium sulphate, and ammonium tartrate, yielded negative results, as regards acidity, when inoculated as in the above experiments.

The results, as shown in the foregoing table, pointed to the production uniformly of more decided acidity than in the earlier experiments. One reason for this was that, with experience, it became possible to prepare a stronger and yet a more transparent and less highly coloured peat decoction. There could be no question that, in the majority of instances, the growth of the peat micro-organisms in the sterile peat decoction resulted in the production of an appreciable amount of acid.

The following table (CLIV.) is still more important as it takes note of plumbo-solucency as well as acidity. Except that a larger bulk of peat decoction was used for cultural purposes, the conditions of experiment were very similar to those recorded in Table CLIII.

TABLE CLIV.  
Showing the RESULT, as regards ACIDITY and PLUMBO-SOLVENCY, of inoculating STERILE PEAT DECOCTION with a Mixture of PEAT MICRO-ORGANISMS.

Experiment.	Description of the Experiment.	Description of the Soil Mixture used in the Inoculations.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water. Phenolphthalein was used as Indicator.	Plumbo-solvency Parts per 100,000. Tested by Upward Filtration of 500 c.c. of the Liquid through 100 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.	Remarks.
1	June 20th, tested June 28th, 1894.— (a.) 500 c.c. sterile peat decoction + 0 in flask. Control experiment. (b.) 500 c.c. sterile peat decoction + 0.5 c.c. peat soil mixture.	4.775 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral- (b.) Slightly acid.	*(a.) 1.2 (b.) 2.4	(a.) 0.0 (b.) 1.0	By plate cultivation the number of bacteria in 0.5 c.c. peat soil mixture was found to be 792. The sample of peat was obtained from the Shipley moorland gathering ground.
2	July 4th, tested July 9th, 1894.— (a.) Same as (a), Experiment 1 (b.) " " (b)	2.535 grms. Settle peat in 500 c.c. sterile water.	(a.) Neutral- (b.) Trace acid.	(a.) 1.2 (b.) 1.8	(a.) 0.2 (b.) 0.4	The sample of peat was obtained from moorland in the neighbourhood of Settle.
3	July 6th, tested July 11th, 1894.— (a.) Same as (a), Experiment 1 (b.) " " (b), "	6.215 grms. Settle peat in 500 c.c. sterile water.	(a.) Neutral- (b.) Trace acid.	(a.) 1.2 (b.) 2.4	(a.) 0.2 (b.) 0.4	In all the experiments, the contents of the control flask remained clear. The contents of the inoculated flask became cloudy from bacterial growth.
4	July 9th, tested July 17th, 1894.— (a.) Same as (a), Experiment 1 (b.) " " (b), "	7.385 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral- (b.) Slightly acid.	(a.) 2.4 (b.) 3.6	(a.) 0.0 (b.) 0.5	By plate cultivation the number of bacteria in 0.5 c.c. soil mixture was found to be 1,463. The moisture in the peat was found to be equal to 86 per cent.

TABLE CLIV.—continued.

Experiment.	Description of the Experiment.	Description of the Soil Mixture used in the Inoculations.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{N}{10}$ Na <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water. Phenolphthalein was used as Indicator.	Plumbo-sol- vency Parts per 100,000. Tested by Upward filtra- tion of 250 c.c. of the liquid through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.	Remarks.
5	July 10th, tested July 18th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), " "	6·408 grms. Morley peat in 500 c.c. sterile water.	(a.) Neutral— (b.) " "	(a.) 1·2 (b.) 1·2	(a.) 0·0 (b.) 0·0	The sample of peat was obtained from the Morley moorland gathering ground at Mytholmroyd.
6	July 16th, tested July 21st, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), " "	8·9 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral— (b.) Acid "	(a.) 1·2 (b.) 2·4	(a.) 0·0 (b.) 1·2	It was noticed that on applying the ferrocyanide of potassium test for iron, the blue colour developed in (b) and not in (a), without the addition of acid; and when acid was added, the colour developed in (b) more quickly than in the case of (a). This was noted whenever the test was applied, i.e., in the cases where (b.) was found to be appreciably acid and (a.) neutral.
7	July 23rd, tested July 30th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), " "	8·985 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral— (b.) Acid "	(a.) 1·2 (b.) 2·4	(a.) 0·4 (b.) 0·8	By plate cultivation the number of bacteria in 0·5 c.c. soil mixture was found to be 440.
8	July 30th, tested August 6th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), " "	8·082 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral— (a.) Acid "	(a.) 2·4 (b.) 3·6	(a.) 0·1 (b.) 0·8	By plate cultivation the number of bacteria in 0·5 c.c. soil mixture was found to be 1,246.
9	Aug. 6th, tested Aug. 16th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), " " (a.) " (a), " " (b.) " (b), " " (a.) " (a), " " (b.) " (b), " "	10·340 grms. Shipley peat in 500 c.c. sterile water.	A (a.) Neutral (b.) f Trace acid. B (a.) Neutral (b.) f Trace acid. C (a.) Neutral (b.) " "	A (a.) 3·0 (b.) 4·8 B (a.) 2·4 (b.) 3·6 C (a.) 1·2 (b.) 1·2	A (a.) 0·2 (b.) 0·4 B (a.) 0·2 (b.) 0·4 C (a.) 0·1 (b.) 0·1	The same peat soil mixture was used to inoculate A, B, and C, but a different sample of peat decoction was used in each case.

10	Aug. 13th, tested Aug. 17th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	17-11 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1-2 (b.) 3-6	(a.) 0-0 (b.) 0-8	550 micro-organisms in 0-5 c.c. peat soil mixture.
11	Aug. 22nd, tested Aug. 27th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	2-334 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1-8 (b.) 4-8	(a.) 0-0 (b.) 2-0	
12	Aug. 28th, tested Aug. 30th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	6-13 grms. Morley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1-8 (b.) 5-4	(a.) 0-2 (b.) 2-0	396 micro-organisms in 0-5 c.c. peat soil mixture.
13	Aug. 29th, tested Sept. 4th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	4-925 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " -	(a.) 1-8 (b.) 1-8	(a.) 0-2 (b.) 0-2	
14	Sept. 4th, tested Sept. 9th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), " (a.) " (a.), " (b.) " (b.), "	6-106 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1-8 (b.) 3-0	A (a.) 0-8 B (a.) 0-0 B (b.) 0-4	It is to be noted that, in all the experiments, only a small amount of peat was added to a considerable bulk of sterile water, and that of this peat soil mixture only minute quantities were added to the sterile peat decoction.  The same peat soil mixture was used to inoculate A and B, but a different sample of peat decoction was used.
			(a.) Neutral - (b.) Acid -	(a.) 0-6 (b.) 1-8		
15	Sept. 10th, tested Sept. 17th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	12-78 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Trace acid.	(a.) 1-2 (b.) 1-8	(a.) 0-4 (b.) 0-6	The sample of peat was obtained from the Morley moorland gathering grounds.
16	Sept. 13th, tested Sept. 19th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	3-542 grms. Morley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1-2 (b.) 2-4	(a.) 0-0 (b.) 1-0	
17	Sept. 18th, tested Sept. 24th, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	7-26 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1-2 (b.) 4-8	(a.) 0-0 (b.) 0-8	
18	Sept. 28th, tested Oct. 2nd, 1894:— (a.) Same as (a.), Experiment 1 (b.) " (b.), "	4-07 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1-2 (b.) 2-4	(a.) 0-4 (b.) 1-0	

TABLE CLIV.—continued.

Experiment.	Description of the Experiment.	Description of the Soil Mixture used in the Inoculations.	Reaction with Lactmoid.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{N}_2\text{S}_2\text{O}_8$ required to neutralise 100 c.c. of the Water Phenolphthalein was used as Indicator.	Plumbe-sol- vency, Parts per 100,000. Tested by Upward Filtra- tion of 25 c.c. of the Liquid through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.	Remarks.
19	Sept. 29th, tested Oct. 7th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), "	5·237 grms. Keighley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 2·4 (b.) 5·6	(a.) 0·5 (b.) 1·0	The sample of peat was obtained from the Keighley moorland gathering grounds.
20	Oct. 2nd, tested Oct. 8th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), "	8·937 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1·2 (b.) 3·6	(a.) 0·0 (b.) 0·4	The peat decoction used in the experiments was made by boiling peat with distilled water filtering through muslin, boiling the filtrate with peat ash, and filtering repeatedly through filter paper until the filtrate was quite transparent, although of a pale yellow to brown sherry colour.
21	Oct. 9th, tested Oct. 15th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), "	8·375 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1·2 (b.) 3·6	(a.) 0·0 (b.) 0·5	
22	Oct. 16th, tested Oct. 22nd, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), "	8·425 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1·2 (b.) 2·4	(a.) 0·0 (b.) 0·5	
23	Oct. 23rd, tested Nov. 2nd, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), "	4·02 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " -	(a.) 2·4 (b.) 2·4	(a.) 0·5 (b.) 0·5	The peat, in all the experiments, was collected in a sterile tube. The tube was weighed, and a small but unknown quantity of the peat dropped into a flask containing 500 c.c. neutral sterile water. The tube was then reweighed, the loss of weight representing the amount of peat used. After shaking the flask for one hour a portion of the peat soil mixture was withdrawn by means of a sterilised pipette, the dropping capacity of which had been previously ascertained, and a definite number of drops added to the sterile peat decoction.
24	Oct. 30th, tested Nov. 8th, 1894.— (a.) Same as (a), Experiment 1 (b.) " (b), "	8·68 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " -	(a.) 3·6 (b.) 4·8	(a.) 1·0 (b.) 1·0	

25	Nov. 6th tested Nov. 12th, 1894 :— (a.) Same as (a), Experiment 1 (b.) " "	5.735 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 3.6	(a.) 0.0 (b.) 0.5
26	Nov. 14th, tested Nov. 22nd, 1894 :— (a.) Same as (a), Experiment 1 (b.) " "	4.035 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " "	(a.) 1.2 (b.) 1.8	(a.) 0.0 (b.) 0.1
27	Nov. 21st, tested Nov. 27th, 1894 :— (a.) Same as (a), Experiment 1 (b.) " "	3.874 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.4	(a.) 0.0 (b.) 0.75
28	Nov. 27th, tested Dec. 6th, 1894 :— (a.) Same as (a), Experiment 1 (b.) " "	6.245 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " "	(a.) 1.2 (b.) 1.2	(a.) 0.1 (b.) 0.1
29	Dec. 6th, tested Dec. 17th, 1894 :— (a.) Same as (a), Experiment 1 (b.) " "	3.491 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 2.4 (b.) 4.8	(a.) 0.4 (b.) 2.0
30	Dec. 13th, tested Dec. 30th, 1894 :— (a.) Same as (a), Experiment 1 (b.) " "	7.94 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 0.6 (b.) 1.2	(a.) 0.0 (b.) 1.0
31	Dec. 19th, 1894, tested Jan. 5th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " "	9.65 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Trace acid.	(a.) 2.4 (b.) 3.6	(a.) 0.0 (b.) 0.2
32	Jan. 22nd, tested Jan. 31st, 1895 :— (a.) Same as (a), Experiment 1 (b.) " "	14.545 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.4	(a.) 0.25 (b.) 0.60
33	March 6th, tested April 6th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " "	11.57 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " "	(a.) 1.2 (b.) 1.2	(a.) 0.0 (b.) 0.0

TABLE CLIV.—continued.

Experiment.	Description of the Experiment.	Description of the Soil Mixture used in the Inoculations.	Reaction with Lactmold.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water. Phenolphthalein was used as Indicator.	Plumbo-sol-venty Parts per 100,000 tested by Upward Filtra- tion of 25 c.c. of the Liquid through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.	Remarks.
34	April 9th, tested April 16th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " " (b), "	8.5 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 3.6	(a.) 0.0 (b.) 0.5	
35	April 30th, tested May 7th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " " (b), "	13.23 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.8 (b.) 3.0	(a.) 0.0 (b.) 0.5	
36	May 13th, tested May 20th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " " (b), "	10.34 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.4	(a.) 0.0 (b.) 0.5	
37	May 21st, tested May 29th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " " (b), "	1.940 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 3.0	(a.) 0.0 (b.) 0.5	
38	May 29th, tested June 4th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " " (b), "	6.2 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.4	(a.) 0.0 (b.) 0.4	
39	May 28th, tested June 18th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " " (b), "	5.6 grms. Kelchley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " "	(a.) 1.2 (b.) 1.2	(a.) 0.0 (b.) 0.0	

40	June 8th, tested June 11th, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	10.5 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 0.6 (b.) 1.2	(a.) 0.0 (b.) 0.25	The sample of peat was obtained from Bradford "low level" gathering ground.
41	June 11th, tested June 22nd, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	4.6 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " -	(a.) 1.2 (b.) 1.2	(a.) 0.0 (b.) 0.0	
42	June 21st, tested June 27th, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	10.6 grms. Bradford peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.6	(a.) 0.0 (b.) 1.75	
43	June 28th, tested July 3rd, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	1.45 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.4	(a.) 0.0 (b.) 1.5	
44	July 2nd, tested July 9th, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	7.3 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 3.0	(a.) 0.0 (b.) 1.0	
45	July 9th, tested July 14th, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	10.0 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 0.6 (b.) 1.2	(a.) 0.0 (b.) 0.4	
46	July 24th, tested August 2nd, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	10.28 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 0.6 (b.) 1.2	(a.) 0.0 (b.) 0.25	
47	July 30th, tested August 6th, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	7.7 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 0.6 (b.) 1.2	(a.) 0.0 (b.) 0.25	
48	Aug. 6th, tested Aug. 13th, 1896 :— (a.) Same as (a), Experiment 1 (b.) " " "	10.8 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.4	(a.) 0.0 (b.) 0.5	



TABLE OLIV.—continued.

Experiment.	Description of the Experiment.	Description of the Soil Mixture used in the Inoculations.	Reaction with Leucomoid.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water. Phenolphthalein was used as Indicator.	Plumbo-sol-veny, Parts per 100,000 tested by Upward Filtra-tion of 25 c.c. of the Liquid through 50 c.c. washed Lead Shot at the Rate of 3 mins. per 50 c.c.	Remarks.
49	Aug. 14th, tested Aug. 19, 1895 :— (a.) Same as (a), Experiment 1 (b.) " (b), " "	5.0 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) Acid -	(a.) 1.2 (b.) 2.4	(a.) 0.0 (b.) 0.8	
50	Aug. 21st, tested Aug. 26th, 1895 :— (a.) Same as (a), Experiment 1 (b.) " (b), " "	19.2 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " "	(a.) 0.6 (b.) 0.6	(a.) 0.0 (b.) 0.0	
51	Aug. 27th, tested Sept. 2nd, 1895 :— (a.) Same as (a), Experiment 1 (b.) " (b), " "	4.3 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral - (b.) " "	(a.) 0.6 (b.) 0.6	(a.) 0.0 (b.) 0.0	

\* A certain amount of  $\frac{N}{10}$   $\text{Na}_2\text{CO}_3$  is needed to give a pink colour with phenol-phthalein as indicator even when the peat decoction is neutral in reaction.

The results show that the addition of a minute amount of peat (i.e., a mixture of peat microbes) to sterile peat decoction may, and usually does under the conditions of experiment, result in the production, in the peat decoction, of acid and plumbo-solvent properties. 51 experiments in all were made; the samples of peat were obtained from Settle moorland, and from Shipley, Morley, Keighley, and Bradford gathering grounds.

The following table (Table CLV.) is comparable to Table CLII., except that 1 per cent. of cane sugar was added to the peat decoction:—

TABLE CLV.

Showing the RESULTS (as regards ACIDITY) of INOCULATING PEAT DECOCTION (+ 1 per cent. CANE-SUGAR) with a MIXTURE of PEAT MICRO-ORGANISMS. 16 experiments with 16 samples of soil and 20 inoculations.

[The samples of peat soil were obtained from the Bentham (Burnmoor) gathering ground.]

Description of the Experiments.	Description of the Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0033 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 1.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 8th, 1893.	12.765 grms. soil in 500 c.c. sterile water.	141 germs in 0.04 c.c.	Per cent. 88	November 23rd, 1893. 5 c.c. with phenolphthalein, sample a, 0.36 c.c.; control, 0.06 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.18; control, 0.0 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ .	7.5
* <i>Experiment No. 2.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 8th, 1893.	4.233 grms. soil in 500 c.c. sterile water.	7 germs in 0.035 c.c.	82	November 24th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ .	2.1
<i>Experiment No. 3.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 15th, 1893.	8.036 grms. soil in 500 c.c. sterile water.	103 germs in 0.035 c.c.	74	November 24th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ .	1.2
* <i>Experiment No. 4.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 15th, 1893.	5.292 grms. soil in 500 c.c. sterile water.	31 germs in 0.04 c.c.	91	November 24th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{n}{10}$ $\text{Na}_2\text{CO}_3$ .	1.2

TABLE CLV.—continued.

Description of the Experiments.	Description of the Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0033 Grams. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 5.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 20° C. 1 control. November 22nd, 1893.	6.446 grms. soil in 500 c.c. sterile water.	71 germs in 0.04 c.c.	Per cent. 71	December 9th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	2.7
* <i>Experiment No. 6.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 20° C. 1 control. November 22nd, 1893.	1.297 grms. soil in 500 c.c. sterile water.	15 germs in 0.035 c.c.	67	December 9th, 1893. 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	2.7
<i>Experiment No. 7.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 29th, 1893.	9.18 grms. soil in 500 c.c. sterile water.	77 germs in 0.04 c.c.	82	December 18th, 1893. 5 c.c. with phenolphthalein, sample a, 0.46 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.24 c.c.; control, 0.06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	8.1
<i>Experiment No. 8.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 29th, 1893.	4.04 grms. soil in 500 c.c. sterile water.	9 germs in 0.035 c.c.	82	December 18th, 1893. Negative results with phenolphthalein as indicator. 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	3.0
<i>Experiment No. 9.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 6th, 1893.	14.335 grms. soil in 500 c.c. sterile water.	294 germs in 0.04 c.c.	87	December 22nd, 1893. 5 c.c. with phenolphthalein, sample a, 0.33 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	3.3
* <i>Experiment No. 10.</i> 1 tube (a) containing sterile peat decoction (+1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 6th, 1893.	5.201 grms. soil in 500 c.c. sterile water.	15 germs in 0.035 c.c.	64	December 22nd, 1893. 5 c.c. with phenolphthalein and lacmoid, negative results.	0.0

TABLE CLV.—*continued.*

Description of the Experiments.	Description of the Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 11.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 13th, 1893.	11.153 grms. soil in 500 c.c. sterile water.	22 germs in 0.04 c.c.	Per cent. 71	January 1st, 1894. 5 c.c. with phenolphthalein, sample a, 0.24 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	2.7
* <i>Experiment No. 12.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 13th, 1893.	7.024 grms. soil in 500 c.c. sterile water.	6 germs in 0.035 c.c.	74	January 1st, 1894. Negative results with phenolphthalein and lacmoid as indicators.	0.0
<i>Experiment No. 13.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 20th, 1893.	8.142 grms. soil in 500 c.c. sterile water.	23 germs in 0.04 c.c.	87	January 12th, 1894. 5 c.c. with phenolphthalein, sample a, 0.54 c.c.; control, 0.06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.13 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	9.3 5
* <i>Experiment No. 14.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 20th, 1893.	3.573 grms. soil in 500 c.c. sterile water.	13 germs in 0.035 c.c.	84	January 12th, 1894. Negative results with phenolphthalein and lacmoid as indicators.	0.0
<i>Experiment No. 15.</i> 3 tubes (a, b, c) containing sterile peat decoction (+ 1 per cent. cane-sugar) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893.	18.937 grms. soil in 500 c.c. sterile water.	56 germs in 0.04 c.c.	82	January 13th, 1894. 5 c.c. with phenolphthalein, samples a and b, 0.54 c.c.; sample c, 0.3 c.c.; control, 0.06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, a, 0.18; b, 0.12; c, 0.06 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	a=9.3 b=7.8 c=3.9
* <i>Experiment No. 16.</i> 3 tubes (a, b, c) containing sterile peat decoction (+ 1 per cent. cane-sugar) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893.	7.894 grms. soil in 500 c.c. sterile water.	18 germs in 0.035 c.c.	87	January 13th, 1894. 5 c.c. with phenolphthalein, sample a, 0.24; samples b, c, 0.06 c.c.; control, 0.06 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, a, 0.06, b and c, 0.0; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	a=3.3 b=0.0 c=0.0

\* Samples of peat soil obtained from a little below the surface level. In all the other experiments the samples of soil were taken from the surface.

The results obtained were very similar in character to those recorded in Table CLII., but they are less significant, since the peat decoction contained a foreign ingredient, viz., cane sugar.

The same remarks apply to Table CLVI. Here the peat decoction was fortified with peptone and salt.

TABLE CLVI.

Showing the RESULTS of INOCULATION of STERILE PEAT DECOCTION (containing PEPTONE and SALT) with a MIXTURE of PEAT MICRO-ORGANISMS. 17 experiments with 16 samples of peat soil, and 22 inoculations of sterile peat decoction.

[The samples of peat soil were obtained from the Bentham (Burnmoor) gathering grounds.]

Description of the Experiments.	Description of the Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. $\frac{N}{10}$ c.c. = 0.0033 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 1.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl) inoculated with 0.04 c.c. soil mixture. Incubated $30^\circ\text{C}$ . 1 control. October 18th, 1893.	6.776 grms. soil in 500 c.c. sterile water.	88 germs in 0.04 c.c.	Per cent. 79	October 23rd, 1893. Negative results with laemoid, 4 c.c. with phenol - phthalein, sample a, 0.54 c.c.; control, 0.38 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	4.5
<i>Experiment No. 2.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl) inoculated with 0.056 c.c. soil mixture. Incubated $30^\circ\text{C}$ . 1 control. October 18th, 1893.	5.51 grms. soil in 500 c.c. sterile water.	54 germs in 0.056 c.c.	75	October 23rd, 1893. Negative results with laemoid, 5 c.c. with phenol - phthalein, sample a, 0.98 c.c.; control, 0.54 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	8.4
<i>Experiment No. 3.</i> 2 flasks (a and b) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl) inoculated each with 0.2 c.c. soil mixture (kept at temperature of room for four days). Incubated $30^\circ\text{C}$ . 1 control. October 22nd, 1893.	6.776 grms. soil in 500 c.c. sterile water.	440 germs in 0.2 c.c. (4 days before inoculations).	79	October 24th, 1893. Negative results with laemoid. 50 c.c. with phenol - phthalein, samples a and b, 1.5 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	a=3.0 b=9.0

TABLE CLVI.—continued.

Description of the Experiments.	Description of the Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. * $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0033 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 4.</i> 2 flasks (a, b) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl), inoculated each with 0.2 c.c. soil mixture. Incubated 30° C. 1 control. October 25th, 1893.	4.934 grms. soil in 500 c.c. sterile water.	250 germs in 0.2 c.c.	Per cent. 75	October 30th, 1893. 5 c.c. with phenolphthalein, sample a, 0.6 c.c.; sample b, 0.66 c.c.; control, 0.36 c.c. $\frac{2}{10} \text{Na}_2\text{CO}_3$ 1 c.c. with lacmoid, samples a and b, 0.36 c.c.; control, 0.24 c.c. $\frac{2}{10} \text{Na}_2\text{CO}_3$ .	$a = 8.4$ $b = 9.0$
<i>Experiment No. 5.</i> 2 flasks (a and b) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl) inoculated each with 0.28 c.c. soil mixture. Incubated 30° C. 1 control. October 25th, 1893.	6.745 grms. soil in 500 c.c. sterile water.	3,915 germs in 0.28 c.c.	74	October 30th, 1893. 1 c.c. with phenolphthalein and with lacmoid, sample a and b, 0.24 c.c.; control, 0.18 c.c. $\frac{2}{10} \text{Na}_2\text{CO}_3$ .	$a = 8.0$ $b = 6.0$
<i>Experiment No. 6.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 1st, 1893.	6.975 grms. soil in 500 c.c. sterile water.	246 germs in 0.04 c.c.	87	November 6th, 1893. Negative result with lacmoid, 5 c.c. with phenol-phthalein, sample a, 0.43 c.c.; control, 0.18 c.c. $\frac{2}{10} \text{Na}_2\text{CO}_3$ .	4.8
<i>Experiment No. 7.</i> 1 tube (a) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl), inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 1st, 1893.	11.159 grms. soil in 500 c.c. sterile water.	144 germs in 0.035 c.c.	80	November 6th, 1893. Negative results with lacmoid and phenolphthalein as indicators.	0.0
<i>Experiment No. 8.</i> 1 tube (a) containing sterile peat decoction (+ 0.1 per cent. peptone and 0.05 per cent. NaCl), inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. November 22th, 1893.	9.18 grms. soil in 500 c.c. sterile water.	77 germs in 0.04 c.c.	82	December 18th, 1893. Negative results with phenol-phthalein. 2 c.c. with lacmoid, sample a, 0.06 c.c.; control, 0.0 c.c. $\frac{2}{10} \text{Na}_2\text{CO}_3$ .	3.0

TABLE CLVI.—*continued.*

Description of the Experiments.	Description of the Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0033 Grms. $\text{Na}_2\text{CO}_3$
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
*Experiment No. 9. 1 tube (a) containing sterile peat decoction (+0.1 per cent. peptone and 0.05 per cent. NaCl), inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. November 29th, 1893.	4.04 grms. soil in 500 c.c. sterile water.	9 germs in 0.035 cc.	Per cent. 82	December 18th, 1893. 5 c.c. with phenolphthalein, sample a, 0.24 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.12 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	4.2
Experiment No. 10. 1 tube (a) containing sterile peat decoction (+0.1 per cent. peptone and 0.05 per cent. NaCl), inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 6th, 1893.	14.335 grms. soil in 500 c.c. sterile water.	294 germs in 0.04 c.c.	87	December 22nd, 1893. 2 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, sample a, 0.24 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	3.9
*Experiment No. 11. 1 tube (a) containing sterile peat decoction (+0.1 per cent. peptone and 0.05 per cent. NaCl) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 6th, 1893.	5.301 grms. soil in 500 c.c. sterile water.	15 germs in 0.035 c.c.	64	December 22nd, 1893. 2 c.c. with phenolphthalein, sample a, 0.24 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, sample a, 0.3 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	6.0
Experiment No. 12. 1 tube (a) containing sterile peat decoction (+0.1 per cent. peptone and 0.05 per cent. NaCl) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 13th, 1893.	11.153 grms. soil in 500 c.c. sterile water.	22 germs in 0.04 c.c.	71	January 1st, 1894. 5 c.c. with phenolphthalein, sample a, 0.24 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ . 2 c.c. with lacmoid, sample a, 0.08 c.c.; control, 0.0 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	2.7
*Experiment No. 13. 1 tube (a) containing sterile peat decoction (+0.1 per cent. peptone and 0.05 per cent. NaCl) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 13th, 1893.	.024 grms. soil in 500 c.c. sterile water.	6 germs in 0.035 c.c.	74	January 1st, 1894. Negative results with lacmoid, 5 c.c. with phenolphthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	1.2

TABLE CLVI.—continued.

Description of the Experiments.	Description of the Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
	Amount of Dilution of the Peat Soil with Sterile Water.	Average No. of Germs contained in the Soil Mixture.	Moisture in the Sample of Soil.		
<i>Experiment No. 14.</i> 1 tube (a) containing sterile peat decoction (+0.1 per cent. peptone and 0.06 per cent. NaCl) inoculated with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 20th, 1893.	8.142 grms. soil in 500 c.c. sterile water.	23 germs in 0.04 c.c.	Per cent. 87	January 12th, 1891. Negative results with lacmoid, 5 c.c. with phenol - phthalein, sample a, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	1.2
* <i>Experiment No. 15.</i> 1 tube (a) containing sterile peat decoction (+0.1 per cent. peptone and 0.06 per cent. NaCl) inoculated with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 20th, 1893.	3.573 grms. soil in 500 c.c. sterile water.	13 germs in 0.035 c.c.	84	January 12th, 1894. Negative results with lacmoid, 5 c.c. with phenol - phthalein, sample a, 0.18 c.c.; control 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	1.2
<i>Experiment No. 16.</i> 2 tubes (a, b) containing sterile peat decoction (+0.1 per cent. peptone and 0.06 per cent. NaCl) inoculated each with 0.04 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893.	18.937 grms. soil in 500 c.c. sterile water.	56 germs in 0.04 c.c.	33	January 13th, 1894. Negative results with lacmoid, 5 c.c. with phenol - phthalein, sample a, and b, 0.18 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	a = 1.2 b = 1.2
* <i>Experiment No. 17.</i> 2 tubes (a, b) containing sterile peat decoction (+0.1 per cent. peptone and 0.06 per cent. NaCl) inoculated each with 0.035 c.c. soil mixture. Incubated 30° C. 1 control. December 27th, 1893.	7.894 grms. soil in 500 c.c. sterile water.	18 germs in 0.035 c.c.	87	January 13th, 1894. Negative results with lacmoid, 5 c.c. with phenol - phthalein, samples a, and b, 0.24 c.c.; control, 0.12 c.c. $\frac{N}{10}$ $\text{Na}_2\text{CO}_3$ .	a = 2.4 b = 2.4

\* Samples of peat soil obtained from a little below the surface level—in all the other experiments the samples of soil were taken from the surface. Where the different indicators give different amounts of acidity, the average amount of acidity is taken.

Although not uncommonly the peat decoction was rendered slightly acid by the growth of the peat microbes, the results have not the same significance as those previously recorded, since the peat decoction was fortified with peptone and salt.

Next to be considered are some experiments carried out under anaerobic conditions, in which peat decoction alone and peat decoction containing glucose were inoculated with a mixture of peat microbes. The results are shown in the two following tables (Tables CLVII. and CLVIII.).



TABLE CLVII.

Showing the RESULT, as regards ACIDITY, of inoculating STERILE PEAT DECOCTION with a MIXTURE of PEAT MICRO-ORGANISMS. Cultivated anaerobically.

[The samples of peat were obtained from the Shipley gathering grounds.]

Experiment.	Description of the Experiment.	Description of the Soil Mixture used in the Inoculations.	Reaction with Lacmoid.	Acidity in Terms of c.c. $\frac{2}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid*.
1	October 16th, tested October 24th, 1894:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	6.425 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) "	(a.) 3.6 (b.) 3.6
2	October 23rd, tested November 15th, 1894:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	4.02 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) "	(a.) 3.6 (b.) 3.6
3	October 30th, tested November 15th, 1894:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	8.96 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) ? Trace acid.	(a.) 3.6 (b.) 6.0
4	November 6th, tested November 14th, 1894:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	5.735 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) "	(a.) 3.6 (b.) 3.6
5	November 14th, tested December 12th, 1894:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	4.085 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) "	(a.) 3.6 (b.) 4.2
6	November 21st, tested December 12th, 1894:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	2.874 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) "	(a.) 3.6 (b.) 4.8
7	November 27th, tested December 12th, 1894:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	6.245 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) Acid	(a.) 3.6 (b.) 6.0
8	December 13th, 1894, tested January 19th, 1895:— (a.) 20 c.c. sterile peat decoction in Roux tube exhausted of oxygen. Control experiment. (b.) 20 c.c. sterile peat decoction + 0.5 c.c. soil mixture. Cultivated anaerobically.	7.94 grms. Shipley peat in 500 c.c. sterile water.	(a.) Neutral (b.) "	(a.) 3.6 (b.) 4.8

\* A certain amount of  $\frac{2}{10}$   $\text{Na}_2\text{CO}_3$  was needed to give a pink colour with phenol-phthalein as indicator even when the peat decoction was neutral in reaction.

TABLE CLVIII.

Showing the RESULT of INOCULATING PEAT DECOCTION (+2 per cent. GLUCOSE) with a MIXTURE of PEAT MICRO-ORGANISMS. Cultivated anaerobically.

[The samples of peat were obtained from the Bentham gathering grounds.]

Description of the Experiments.	Description of the Peat Soil Mixture used for the Inoculations.			Remarks.	Acidity in Terms of c.c. $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Liquid. 1 c.c. = 0.0033 Grm. $\text{Na}_2\text{CO}_3$ .
	Amount of dilution of the Peat Soil with Sterile Water.	Average No. of Anaerobic Germs in the Soil Mixture.	Moisture in the Sample of Peat Soil.		
<i>Experiment No. 1.</i> 1 Roux tube containing sterile peat decoction (+2 per cent. glucose) inoculated with 0.33 c.c. soil mixture. Cultivated anaerobically. 1 control. Incubated 30 C°. November 8th, 1893.	12.765 grms. peat in 500 c.c. sterile water.	113 germs (anaerobic) in 0.33 c.c.	Per cent. 83	November 20th, 1893. 5 c.c. with phenolphthalein as indicator, control, 0.66 c.c.; sample, 0.6 c.c. $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ . 5 c.c. with lacmoid, control, 0.0 c.c.; sample, 0.6 c.c. $\frac{10}{10}$ $\text{Na}_2\text{CO}_3$ .	11.6
<i>Experiment No. 2.</i> Do. November 15th, 1893.	4.233 Do.	No record	83	No growth occurred.	No growth occurred.
<i>Experiment No. 3.</i> Do. November 22nd 1893.	6.446 Do.	178 anaerobic germs in 0.33 c.c.	71	" " "	
<i>Experiment No. 4.</i> 1 c.c. soil mixture. November 29th, 1893.	9.180 Do.	286 germs in 1 c.c.	82	" " "	
<i>Experiment No. 5.</i> Do. December 6th, 1893.	14.335 Do.	50 Do.	87	" " "	
<i>Experiment No. 6.</i> Do. December 13th, 1893.	11.153 Do.	114 Do.	71	" " "	
<i>Experiment No. 7.</i> Do. December 20th, 1893.	8.142 Do.	13 Do.	87	" " "	
<i>Experiment No. 8.</i> Do. December 27th, 1893.	18.937 Do.	67 Do.	83	" " "	

The marked acidity in Experiment No. 1, and the subsequent failure in the remaining experiments is possibly to be accounted for in the following way. Many peat micro-organisms are facultative anaerobes, but grow most luxuriantly under aerobic conditions. In the first experiment, notwithstanding all care, some traces of oxygen possibly remained in the cultivation and allowed growth and acidity to take place. In the other experiments, the oxygen being entirely removed, the bacteria were unable to thrive anaerobically in so poor a nutritive medium as peat decoction.

It will be seen that the results, with a very few exceptions, were practically negative, either when peat decoction alone or peat decoction plus glucose was used for cultivation purposes. It would thus appear that anaerobic conditions are less favourable than aerobic for the production of acid.

While the foregoing experiments were in progress, pure cultures of peat and peaty water microbes were being attentively studied. These organisms were isolated by the usual gelatine plate culture method from peat, peaty water, or from the peat decoction cultures, which, when inoculated with these substances, had as a result of such inoculation developed acidity. These pure cultures of peat microbes

were separately introduced into peat decoction of varied composition with the following results:—

TABLE CLIX.

Showing the RESULT (as regards ACIDITY) of INOCULATING VARIOUS STERILE PEAT DECOCTIONS with PURE CULTIVATIONS of MICRO-ORGANISMS isolated from PEAT SOIL.

(1.) The inoculation of sterile peat decoction (+ 0) with micro-organisms 1 to 11 inclusive, and microbes A and B. 26 experiments and 89 inoculations.

(2.) The inoculation of sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. NaCl) with micro-organisms 2, 3, 5, and 11. 4 experiments and 4 inoculations.

(3.) The inoculation of sterile peat decoction (+ 1 per cent. cane-sugar) with micro-organisms 1 to 19 inclusive, and microbes A, B, and C. 22 experiments and 22 inoculations.

Experiment No.	Incubated at	Number of Control Experiments.	Date of Inoculation.	Date of subsequent Testing for Acidity.	Description of Peat Decoction.	Description of Peat Micro-organisms.	Remarks.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
1 (a)	C. 30°	1	1893. Oct. 27	1893. Nov. 18	Sterile peat decoction.	No. 1	Negative results with phenol-phthalein and lacmoid as indicators.	0
2 (a)	"	2	Nov. 6	Nov. 21	" "	1	" "	0
(b)	"	"	"	Dec. 1	" "	"	" "	0
3 (a)	"	1	Oct. 22	Nov. 4	" "	2	" "	0
4 (a)	"	"	" 27	" 18	" "	2	" "	0
5 (a)	"	2	Nov. 6	" 21	" "	2	" "	0
(b)	"	"	"	Dec. 1	" "	"	" "	0
" (a)	"	1	Oct. 22	Nov. 4	" "	3	" "	0
7 (a)	"	"	" 27	" 18	" "	3	" "	0
8 (a)	"	2	Nov. 6	" 21	" "	3	" "	0
(b)	"	"	"	Dec. 1	" "	"	" "	0
9 (a)	"	1	Oct. 27	Nov. 18	" "	4	" "	0
10 (a)	"	2	Nov. 6	" 21	" "	4	" "	0
(b)	"	"	"	Dec. 1	" "	"	" "	0
11 (a)	"	1	Oct. 22	Oct. 30	" "	5	" "	0
12 (a)	"	"	" 27	Nov. 4	" "	5	" "	0
13 (a)	"	2	Nov. 6	" 21	" "	5	" "	0
(b)	"	"	"	Dec. 1	" "	"	" "	0
14 (a)	"	1	" 3	Nov. 18	" "	6	" "	0
15 (a)	"	2	" 6	" 21	" "	6	" "	0
(b)	"	"	"	Dec. 1	" "	"	" "	0
16 (a)	"	1	" 3	Nov. 18	" "	7	" "	0
17 (a)	"	"	" 6	" 21	" "	7	" "	0
(b)	"	"	"	Dec. 1	" "	"	" "	0
18 (a)	"	1	" 3	Nov. 18	" "	8	" "	0

TABLE CLIX.—*continued.*

Experiment No.	Incubated at	Number of Control Experiments.	Date of Inoculation.	Date of subsequent Testing for Acidity.	Description of Peat Decoction.	Description of Peat Micro-organism.	Remarks.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
19 (a)	C. 30°	2	1893. Nov. 6	1893. Nov. 21	Sterile peat decoction.	No. 8	Negative results with phenol-phthalein and lacmoid as indicators.	0
" (b)	"	"	"	Dec. 1	" "	"	" "	0
20 (a)	"	2	" 6	Nov. 21	" "	9	" "	0
" (b)	"	"	"	Dec. 1	" "	"	" "	0
21 (a)	"	1	" 3	Nov. 18	" "	10	" "	0
22 (a)	"	2	" 6	" 21	" "	10	" "	0
" (b)	"	"	"	Dec. 1	" "	"	" "	0
23 (a)	"	1	" 3	Nov. 18	" "	11	" "	0
24 (a)	"	2	" 6	" 21	" "	11	" "	0
" (b)	"	"	"	Dec. 1	" "	"	" "	0
25 (a)	"	2	" 6	Nov. 21	" "	A	" "	0
" (b)	"	"	"	Dec. 1	" "	"	" "	0
26 (a)	"	2	" 6	Nov. 21	" "	B	" "	0
" (b)	"	"	"	Dec. 1	" "	"	" "	0
27 (a)	"	1	Oct. 22	Oct. 28	Sterile peat decoction (containing 1 per cent. peptone and 0.5 per cent. NaCl).	2	" "	0
28 (a)	"	"	" "	Nov. 4	" "	3	" "	0
29 (a)	"	"	" "	Oct. 28	" "	5	" "	0
30 (a)	"	"	Nov. 3	Nov. 6	" "	11	" "	0
31 (a)	"	"	Dec. 11	Dec. 22	Sterile peat decoction (containing 1 per cent. cane-sugar).	1	" "	0
32 (a)	"	"	" "	" "	" "	2	" "	0
33 (a)	"	"	" "	" "	" "	3	Positive results with phenol-phthalein and lacmoid as indicators.	10.8
34 (a)	"	"	" "	" "	" "	4	Negative results with phenol-phthalein and lacmoid as indicators.	0
35 (a)	"	"	" "	" "	" "	5	" "	0
36 (a)	"	"	" "	" "	" "	6	" "	0
37 (a)	"	"	" "	" "	" "	7	" "	0
38 (a)	"	"	" "	" "	" "	8	Positive results with phenol-phthalein and lacmoid as indicators.	13.2
39 (a)	"	"	" "	" "	" "	9	" "	7.2
40 (a)	"	"	" "	" "	" "	10	Negative results with phenol-phthalein and lacmoid as indicators.	0
41 (a)	"	"	" "	" "	" "	11	" "	0

TABLE CLIX.—*continued.*

Experiment No.	Incubated at	Number of Control Experiments.	Date of Inoculation.	Date of subsequent Testing for Acidity.	Description of Peat Decoction.	Description of Peat Micro-organisms.	Remarks.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the liquid. 1 c.c. = 0.0083 Grms. $\text{Na}_2\text{CO}_3$ .
42 (a)	C. 30°	1	1893. Dec. 11	1893. Dec. 22	Sterile peat decoction (containing 1 per cent. cane-sugar).	No. 12	Positive results with phenol-phthalein and lacmoid as indicators.	1.2
43 (a)	"	"	" "	" "	" "	13	Negative results with phenol-phthalein and lacmoid as indicators.	0
44 (a)	"	"	" "	" "	" "	14	" "	0
45 (a)	"	"	" "	" "	" "	15	" "	0
46 (a)	"	"	" "	" "	" "	16	Positive results with phenol-phthalein and lacmoid as indicators.	1.2
47 (a)	"	"	" "	" "	" "	17	Negative results with phenol-phthalein and lacmoid as indicators.	0
48 (a)	"	"	" "	" "	" "	18	Positive results with phenol-phthalein and lacmoid as indicators.	8.4
49 (a)	"	"	" "	" "	" "	19	Negative results with phenol-phthalein and lacmoid as indicators.	0
50 (a)	"	"	" "	" "	" "	A	Positive results with phenol-phthalein and lacmoid as indicators.	10.8
51 (a)	"	"	" "	" "	" "	B	" "	10.8
52 (a)	"	"	" "	" "	" "	C	" "	8.4

Micro-organisms A, B, C isolated by anaerobic cultivation and found to be facultative anaerobes.

Micro-organisms 1 to 19 inclusive isolated by aerobic plate cultivation in the usual way.

It will be noted that a negative result was obtained in all cases in which either peat decoction alone\* or peat decoction fortified with peptone and salt was used for cultivation purposes. But, when peat decoction to which cane-sugar had been added was employed, microbes 3, 8, 9, 12, 16, 18, A, B and C yielded positive results as regards acidity.

In the above table, however, are not included the two microbes (Peat bacterium O and Peat bacterium Q) described in Addendum H. of Mr. Power's 1893 report, which beyond doubt rendered peat decoction alone (i.e., containing no foreign ingredient) both acid and

\*At the early period (1893) in the inquiry, during which the foregoing experiments were carried out, complete success had not been attained in making a satisfactory peat decoction for cultural purposes.

plumbo-solvent in character. They were isolated from peat soil, and were also encountered on rare occasions in peaty water.

The more important features of the foregoing tables may be briefly summarised as follows :—

Sterile peat decoction, made solely from peat, when inoculated with a mixture of peat microbes or of "peat water" micro-organisms, not uncommonly acquires acid and plumbo-solvent properties. Pure cultures of peat or "peaty water" microbes, when separately introduced into sterile peat decoction, usually fail to render the liquid appreciably acid. A minority, two in number (Peat bacterium O and Peat bacterium Q), are capable of conferring acid and plumbo-solvent properties on a decoction made solely from peat. The following is a brief description of these microbes :—

**DESCRIPTION ON TWO BACTERIA (PEAT BACTERIUM O AND PEAT BACTERIUM Q) ISOLATED FROM PEAT, WHICH WHEN GROWN IN PEAT DECOCTION GAVE TO THE LIQUID ACID REACTION AND PLUMBO-SOLVENT ABILITY.**

**DESCRIPTION IN TABULAR FORM OF TWO BACTERIA WHICH, ISOLATED FROM PEAT SOIL, WOULD APPEAR TO BE CAUSALLY RELATED TO THE OBSERVED ACIDITY OF MOIST SOIL ON MOORLAND GATHERING GROUNDS.**

Peat Bacterium O.	Peat Bacterium Q.
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(A.) WHERE FOUND.

Found in peat soil—rarely in peat water.

(B.) HOW ISOLATED.

Isolated directly from peat soil by gelatine plate cultivation; and also, indirectly, by inoculating sterile peat decoction with an exceedingly small amount of peat soil, and, in the cases where acidity was produced, making plate cultivations from the liquid.

(C.) MORPHOLOGICAL CHARACTERS.

The cells, which are irregularly grouped together, appear at first like cocci, but careful observation shows that in reality one diameter slightly exceeds the other. The cells are non-motile.

(E.) BIOLOGICAL CHARACTERS.

There is no liquefaction of the gelatine.

(a.) Growth in Gelatine Plate and "Roll" Cultivations.

(1.) *Macroscopic appearances* :—The chief points to be noted in studying the growth of the superficial colonies are—

The iridescent, almost transparent, and film-like character of the young colonies.

The rapid rate of growth unaccompanied by any liquefaction of the gelatine.

The irregular manner in which the colonies spread over the nutrient surface, and the irregular thickening of the bacterial mass.

The final appearance of the colonies as white opaque plates, with lobed, fissured, and raised borders, and the granular wrinkled character of their surfaces.

The deep colonies occur as small white bodies more or less circular in shape, which either remain imbedded in the nutrient gelatine, or, by reaching the surface in their growth, spread out superficially or project as small papillae.

This bacterium resembles O very closely, but the colonies do not grow or spread so quickly and are not so transparent in character.

The ultimate size of the colonies is less, and the thickening of the bacterial mass as growth proceeds is greater and more unequal.

Practically the same as in O.

Peat Bacterium O.	Peat Bacterium Q.
<p>(1.) <i>Microscopic appearances (under a low power)</i>.:—The superficial colonies are greyish-brown in colour. The remains of the original colony can usually be seen near the centre as a dark spot, and from this the colour fades towards the periphery; the edge in the older colonies, however, is dark owing to its greater thickness. The colonies have a granular and striated appearance.</p> <p>The deep colonies show no special peculiarities; they are dark brown in colour and faintly granular in structure.</p>	<p>The colonies are more opaque, and their colour darker, otherwise the appearances are the same as in O.</p>
<p>(b.) <i>Growth in Gelatine Puncture Cultivations.</i></p> <p>A white colourless growth appears along the line of the inoculation, composed of numberless small colonies which have become confluent—the puncture has thus a granular appearance.</p> <p>The marked development of gas which occurs gives rise to the formation of gas spaces and fissures throughout the substance of the nutritive medium.</p> <p>The growth on the surface is comparable to the growth of the superficial colonies in plate cultivations. At first a thin bluish-white iridescent film forms at the point of inoculation. Later the colony becomes opaque and granular in character, and the border, when it has ceased to spread, becomes irregularly thickened and raised. In old cultivations furrows and radial thickenings run in tortuous lines over the surface of the growth.</p>	<p>The appearances are nearly the same as in the case of O, but the surface growth is more limited in extent, and of greater thickness.</p>
<p>(c.) <i>Growth in Gelatine Streak Cultivations.</i></p> <p>The growth resembles an elongated superficial colony from a plate culture. It begins first as a bluish-white film spreading in an irregular fashion on either side of the inoculation stroke. Later the surface of the growth becomes opaque and granular, and the border irregularly thickened.</p>	<p>The appearances are nearly the same as in the case of O, but the growth spreads less in a lateral direction, and is thicker, especially along the edges.</p>
<p>(d.) <i>Growth in Bouillon Cultivations.</i></p> <p>The liquid becomes cloudy; but there is no pellicle formation. Gradually a white bacterial deposit collects at the bottom of the tube. The liquid acquires an acid reaction.</p>	
<p>(e.) <i>Growth in Agar Plate Cultivations.</i></p> <p>Lustrous white irregularly-shaped colonies. Not characteristic.</p>	
<p>(f.) <i>Growth in Agar Puncture Cultivations.</i></p> <p>A white growth develops on the surface, and a faint growth along the stab. Numerous gas spaces and fissures appear throughout the substance of the nutritive medium.</p>	
<p>(g.) <i>Growth in Roux Tubes containing Gelatine under Anaerobic Conditions.</i></p> <p>No growth appeared.</p>	<p>Growth very slow and imperfect.</p> <p>(1.) <i>Macroscopic appearances</i>.:—The deep colonies look like little white dots. The superficial colonies appear as small white semi-transparent films with irregular margins.</p> <p>(2.) <i>Microscopic appearances (under a low power)</i>.:—The deep colonies are yellowish in colour, more or less circular in shape, and faintly granular in structure. The superficial colonies appear of a yellowish colour near the centre, where the remains of the original colony can usually be seen as a darker spot. The colour fades almost to transparency towards the periphery. The borders are irregular, and the colonies have a slightly granular and creased appearance.</p>
<p>(h.) <i>Growth in Peat Decoction.</i></p> <p>(The peat decoction was prepared by boiling peat with distilled water, straining through muslin, boiling with peat charcoal, and filtering very slowly through filter paper. The filtration was repeated until the liquid came through perfectly transparent, but of a bright yellow, or brown colour.)</p>	

## Peat Bacterium O.

## Peat Bacterium Q.

(i.) *Anaerobic Cultivations in Sterile Peat Decoctions + 2 per cent. Glucose for Acidity.*

The figures referring to the acidity are in terms of c.c.  $\frac{8}{10}$   $\text{Na}_2\text{CO}_3$  required to neutralise 100 c.c. of the liquid. Phenol-phthalein as indicator.)

## Experiment 1.

December 11, 1893. Tested January 6, 1894. Incubated 20° C.

(1.) 10 c.c. sterile peat decoction + 2 per cent. glucose in Roux tube. Cultivated anaerobically. No growth took place. Control experiment.

Acidity = 1'20. Neutral reaction with lacmoid.

(2.) 10 c.c. as above, but inoculated with Peat bacterium O.

Acidity = 12'0. Acid reaction with lacmoid.

(1.) 10 c.c. sterile peat decoction + 2 per cent. glucose in Roux tube. Cultivated anaerobically. No growth took place. Control experiment.

Acidity = 1'20. Neutral reaction with lacmoid.

(2.) 10 c.c. as above, but inoculated with Peat bacterium Q.

Acidity = 12'0. Acid reaction with lacmoid.

## Experiment 2.

December 14, 1893. Tested January 6, 1894. Incubated 20° C.

Conditions same as in Experiment 1, but no growth took place. Probably in Experiment 1 traces of oxygen were present in the cultivation.

(1.) 10 c.c. sterile peat decoction + 2 per cent. glucose in Roux tube. Cultivated anaerobically. No growth took place. Control experiment.

Acidity = 1'20. Neutral reaction with lacmoid.

(2.) 10 c.c. as above, but inoculated with Peat bacterium Q.

Acidity = 12'0. Acid reaction with lacmoid.

(j.) *Aerobic Cultivations in Sterile Peat Decoction for acidity.*

(The figures denote the acidity in terms of c.c.  $\frac{8}{10}$   $\text{Na}_2\text{CO}_3$  required to neutralise 100 c.c. of the liquid. Phenol-phthalein as indicator. A different peat decoction was used in each experiment.)

December 9, 1893. Tested January 1, 1894. Four tubes each containing 10 c.c. sterile peat decoction inoculated with Peat bacterium O. One control experiment.

Growth took place in all the tubes with the exception of the control, but the results were negative as far as acidity was concerned.

December 23, 1893. Tested January 1, 1894. (a.) 1 tube containing 10 c.c. sterile peat decoction (+ 1 per cent. peptone and 0'5 per cent. salt) inoculated with Peat bacterium O. (b.) One control experiment.

(a.) Acidity = 22'0. Acid - } reaction with  
(b.) " = 12'0. Neutral } lacmoid.

December 25, 1893. Tested January 3, 1894. (a.) One tube containing sterile peat decoction inoculated with Peat bacterium O. (b.) One control experiment.

(a.) Acidity = 12'0. Acid - } reaction with  
(b.) " = 3'6. Neutral } lacmoid.

January 1. Tested January 11, 1894. Experiments with peat decoctions containing sodium phosphate (as much as could be dissolved), calcium phosphate (as much as could be dissolved), magnesium sulphate (1 per cent.), and ammonium tartrate (1 per cent.), yielded negative results as regards acidity.

January 9. Tested January 13, 1894. Four tubes (a), (b), (c), (d), containing sterile peat decoction inoculated with Peat bacterium O. Four control tubes (e), (f), (g), (h).

(a.) Acidity = 12'0. Acid - } reaction with  
(b.) " = 10'8. " } lacmoid.  
(c.) " = 10'8. " }  
(d.) " = 10'8. " }

November 21. Tested November 29, 1893. Two tubes (a), (b), containing sterile peat decoction (+ 1 per cent. cane sugar), inoculated each with Peat bacterium Q. (c.) One control experiment.

(a.) Acidity = 8'4. Acid } reaction with  
(b.) " = 8'4. " } lacmoid.

## Control Experiment.

(c.) Acidity = 1'2. Neutral reaction with lacmoid.

December 1. Tested December 9, 1893. One tube (a) containing sterile peat decoction (+ 1 per cent. cane sugar) inoculated with Peat bacterium Q. (b.) One control experiment.

(a.) Acidity = 3'6. Neutral reaction with lacmoid.

## Control Experiment.

(b.) Acidity = 2'4. Neutral reaction with lacmoid.

December 1. Tested December 9, 1893. One tube (a) containing sterile peat decoction (+ 1 per cent. cane sugar) inoculated with Peat bacterium Q. (b.) One control experiment.

(a.) Acidity = 12'0. Acid - } reaction with  
(b.) " = 2'4. Neutral } lacmoid.

December 1. Tested December 9, 1893. An experiment with peat decoction + 0, and another with peat decoction + 0'1 per cent. peptone and 0'05 per cent. salt, yielded both negative results as regards acidity.



## Peat Bacterium O.

## Control Experiments

(e.) Acidity = 0.4.8. Neutral } reaction with  
 (f.) " = 0.4.8. " } lacmoid.  
 (g.) " = 0.4.8. " }  
 (h.) " = 0.4.8. " }

January 19. Tested January 23, 1894. One tube (a) containing sterile peat decoction inoculated with Peat bacterium O. One control experiment (b).

(a.) Acidity = 9.6. Acid } reaction with  
 (b.) " = 3.6. Neutral } lacmoid.

February 15. Tested February 19, 1894. (a.) One tube containing sterile peat decoction inoculated with Peat bacterium O. (b.) One control experiment.

(a.) Acidity = 2.4. Acid } reaction with  
 (b.) " = 1.2. Neutral } lacmoid.

March 2. Tested March 5, 1894. (a.) One tube containing sterile peat decoction inoculated with Peat bacterium O. (b.) One control experiment.

(a.) Acidity = 7.2. Acid } reaction with  
 (b.) " = 2.4. Neutral } lacmoid.

June 17. Tested June 25, 1894. Four tubes (a), (b), (c), (d), containing sterile peat decoction inoculated each with Peat bacterium O. (e.) One control experiment.

(a.) Acidity = 2.4. Acid } reaction with  
 (b.) " = 2.4. " } lacmoid.  
 (c.) " = 2.4. " }  
 (d.) " = 2.4. " }

## Control Experiment.

(a.) Acidity = 1.2. Neutral reaction with lacmoid.

June 24. Tested June 28, 1894. Four tubes (a), (b), (c), (d), containing sterile peat decoction inoculated each with Peat bacterium O. (e.) One control experiment.

(a.) Acidity = 4.8. Acid } reaction with  
 (b.) " = 4.8. " } lacmoid.  
 (c.) " = 4.8. " }  
 (d.) " = 4.8. " }

## Control Experiment.

(a.) Acidity = 1.2. Neutral reaction with lacmoid.

## Peat Bacterium Q.

December 9. Tested January 1, 1894. Four tubes containing sterile peat decoction inoculated as above. Negative results as regards acidity.

December 23. Tested January 1, 1894. One tube (a) containing sterile peat decoction (+ 1 per cent. peptone and 0.5 per cent. salt) inoculated as above. (b.) One control experiment.

(a.) Acidity = 19.2. Acid } reaction with  
 (b.) " = 12.0. Neutral } lacmoid.

December 25. Tested January 3, 1894. One tube (a.) containing sterile peat decoction inoculated as above. (b.) One control experiment.

(a.) Acidity = 12.0. Acid } reaction with  
 (b.) " = 3.6. Neutral } lacmoid.

January 1. Tested January 11, 1894. Experiments with peat decoctions containing one of the following substances:—Sodium phosphate (as much as could be dissolved), calcium phosphate (as much as could be dissolved), magnesium sulphate (1 per cent.), and ammonium tartrate (1 per cent.), yielded negative results as regards acidity.

January 9. Tested January 20, 1894. Four tubes (a), (b), (c), (d), containing sterile peat decoction inoculated as above. Four control experiments (e), (f), (g), (h).

(a.) Acidity = 10.6. Acid } reaction with  
 (b.) " = 8.4. " } lacmoid.  
 (c.) " = 8.4. " }  
 (d.) " = 8.4. " }

## Control Experiments.

(e.) Acidity = 4.8. Neutral } reaction with  
 (f.) " = 4.8. " } lacmoid.  
 (g.) " = 4.8. " }  
 (h.) " = 4.8. " }

January 19. Tested January 23, 1894. One tube (a.) containing sterile peat decoction inoculated as above. (b.) One control experiment.

(a.) Acidity = 8.4. Acid } reaction with  
 (b.) " = 3.6. Neutral } lacmoid.

January 27. Tested January 30, 1894. One tube (a.) containing sterile peat decoction inoculated as above. (b.) One control experiment.

(a.) Acidity = 2.4. Acid } reaction with  
 (b.) " = 1.2. Neutral } lacmoid.

February 15. Tested February 19, 1894. One tube (a.) containing sterile peat decoction inoculated as above. (b.) One control experiment.

(a.) Acidity = 2.4. Acid } reaction with  
 (b.) " = 1.2. Neutral } lacmoid.

March 2. Tested March 5, 1894. One tube (a.) containing sterile peat decoction inoculated as above. (b.) One control experiment.

(a.) Acidity = 7.2. Acid } reaction with  
 (b.) " = 2.4. Neutral } lacmoid.

June 17. Tested June 23, 1894. Four tubes (a), (b), (c), (d), containing sterile peat decoction inoculated each as above. (e.) One control experiment.

(a.) Acidity = 2.4. Acid } reaction with  
 (b.) " = 2.4. " } lacmoid.  
 (c.) " = 2.4. " }  
 (d.) " = 2.4. " }

Peat Bacterium O.	Peat Bacterium Q.									
	Control Experiment. (a.) Acidity = 1.2. Neutral reaction with lacmoid.									
	June 24. Tested June 28, 1894. Four tubes (a), (b), (c), (d), containing sterile peat decoction inoculated each as above. (a.) One control experiment.									
	<table><tr><td>(a.) Acidity = 4.8.</td><td>Acid</td><td rowspan="4">} reaction with lacmoid.</td></tr><tr><td>(b.) " = 4.8.</td><td>"</td></tr><tr><td>(c.) " = 4.8.</td><td>"</td></tr><tr><td>(d.) " = 4.8.</td><td>"</td></tr></table>	(a.) Acidity = 4.8.	Acid	} reaction with lacmoid.	(b.) " = 4.8.	"	(c.) " = 4.8.	"	(d.) " = 4.8.	"
(a.) Acidity = 4.8.	Acid	} reaction with lacmoid.								
(b.) " = 4.8.	"									
(c.) " = 4.8.	"									
(d.) " = 4.8.	"									
	Control Experiment. (a.) Acidity = 1.2. Neutral reaction with lacmoid.									

(k.) *Aerobic Cultivations in Sterile Peat Decoction for Acidity and Plumbo-solvency.*

The action on lead was tested by upward filtration through 50 c.c. lead shot at the rate of 3 mins. per 50 c.c.

The figures referring to the acidity represent the number of c.c.  $\frac{N}{10}$   $\text{Na}_2\text{CO}_3$  required to neutralise 100 c.c. of the liquid.

The figures referring to the plumbo-solvency represent in parts per 100,000 the lead dissolved by the liquid.

A different peat decoction was used in each experiment.

Experiment 1.

March 23. Tested March 28, 1894. Incubated 20° C.

(a.) 500 c.c. sterile peat decoction in flask.	Control experiment.
(b.) " " " " "	inoculated with Peat bacterium O.
(c.) " " " " "	" " " " " Q.
Acidity {	(a.) = 0.98. Neutral reaction with lacmoid.
	(b.) = 3.36. Acid " " "
	(c.) = 3.36. " " " "
Plumbo-solvency {	(a.) = 0.0.
	(b.) = 2.0.
	(c.) = 2.0.

The plumbo-solvency was difficult to estimate accurately, probably owing to the brown colour of the liquid and the presence of iron.

Experiment 2.

April 9. Tested May 21, 1894. Not incubated.

(a.) 500 c.c. sterile peat decoction in flask.	Control experiment.
(b.) " " " " "	inoculated with Peat bacterium O.
(c.) " " " " "	" " " " " Q.
Acidity {	(a.) = No record. Neutral reaction with lacmoid.
	(b.) = " " " " " Acid " " "
	(c.) = " " " " " " " "
Plumbo-solvency {	(a.) = 0.0.
	(b.) = 0.8.
	(c.) = 0.8.

It was noticed on applying the ferrocyanide test for iron that the blue colour developed in (b), (c), and not in (a) without the addition of acid. When acid was used the colour developed more quickly in (b), (c), than in the case of (a). The above was noted whenever the test was applied, i.e., in the cases where (b), (c), were found to be appreciably acid, and (a) neutral.

Experiment 3.

May 23. Tested May 31, 1894. Incubated 20° C.

(a.) 500 c.c. sterile peat decoction in flask.	Control experiment.
(b.) " " " " "	inoculated with Peat bacterium O.
(c.) " " " " "	" " " " " Q.
Acidity {	(a.) = 1.2. Neutral reaction with lacmoid.
	(b.) = 3.4. Acid " " "
	(c.) = 2.4. " " " "
Plumbo-solvency {	(a.) = 0.0.
	(b.) = 1.0.
	(c.) = 1.0.

## Experiment 4.

June 8. Tested June 13. Incubated 30° C.

(a.)	500 c.c. sterile peat decoction in flask.	Control experiment.	
(b.)	" " " "	inoculated with Peat bacterium	Q.
(c.)	" " " "	" " " "	Q.
Acidity			
	(a.)	= 1'2.	Neutral reaction with lacmoid.
	(b.)	= 3'0.	Acid " "
	(c.)	= 3'0.	" " "
Plumbo-solvency			
	(a.)	= 0'0.	
	(b.)	= 1'2.	
	(c.)	= 0'8.	

## Experiment 5.

June 14. Tested June 16. Not incubated.

(a.)	500 c.c. sterile peat decoction in flask.	Control experiment.	
(b.)	" " " "	inoculated with Peat bacterium	Q.
(c.)	" " " "	" " " "	Q.
Acidity			
	(a.)	= 1'2.	Neutral reaction with lacmoid.
	(b.)	= 2'9.	Acid " "
	(c.)	= 2'9.	" " "
Plumbo-solvency			
	(a.)	= 0'0.	
	(b.)	= 1'6.	
	(c.)	= 1'6.	

## Experiment 6.

June 19. Tested June 21, 1894. Not incubated.

(a.)	500 c.c. sterile peat decoction in flask.	Control experiment.	
(b.)	" " " "	inoculated with Peat bacterium	Q.
(c.)	" " " "	" " " "	Q.
Acidity			
	(a.)	= 1'2.	Neutral reaction with lacmoid.
	(b.)	= 3'6.	Acid " "
	(c.)	= 3'6.	" " "
Plumbo-solvency			
	(a.)	= 0'0.	
	(b.)	= 2'4.	
	(c.)	= 2'4.	

## Experiment 7.

June 21. Tested June 23, 1894. Not incubated.

(a.)	500 c.c. sterile peat decoction in flask.	Control experiment.	
(b.)	" " " "	inoculated with Peat Bacterium	Q.
(c.)	" " " "	" " " "	Q.
Acidity			
	(a.)	= 1'2.	Neutral reaction with lacmoid.
	(b.)	= 2'4.	Acid " "
	(c.)	= 2'4.	" " "
Plumbo-solvency			
	(a.)	= 0'4.	
	(b.)	= 1'5.	
	(c.)	= 1'5.	

## Experiment 8.

June 23. Tested June 28, 1894. Not incubated.

(a.)	500 c.c. sterile peat decoction in flask.	Control experiment.	
(b.)	" " " "	inoculated with Peat bacterium	Q.
(c.)	" " " "	" " " "	Q.
Acidity			
	(a.)	= 2'4.	Neutral reaction with lacmoid.
	(b.)	= 3'6.	Acid " "
	(c.)	= 3'6.	" " "
Plumbo-solvency			
	(a.)	= 0'4.	
	(b.)	= 1'2.	
	(c.)	= 1'2.	

## C.—CONCLUSIONS AS REGARDS THE CAUSE OF THE ACIDITY OF MOORLAND WATERS.

In seeking to trace the antecedent cause of the acidity of moorland waters, three theories advanced as explanatory must needs be considered.

1. *Acid rain-water*, the acidity being held by competent authorities to be derived from the smoke of manufacturing towns.

It has been shown in this report that rain-water, collected in the country, far away from the smoke of big manufacturing towns, is neutral and non-plumbo-solvent in character. But it has also been proved that rain-water collected on high moorland gathering grounds,

not far remote from large manufacturing centres, may be possessed of appreciable acid and plumbo-solvent properties. In these experiments, precautions were taken to exclude from the collecting apparatus the "splashings" from peat. But it cannot be said with absolute certainty that this object was always attained; because it is impossible to estimate how far in storm time the "splashings" may travel. However this may be, there can be no question that the degree of acidity and plumbo-solvent ability observed in the rain-water is quite insufficient to cause the extreme acidity and vigorous solvent action on lead observed in many moorland waters. And the facts established in relation to the filtration of neutral water through peat and the bringing of neutral water into sustained contact with peat have, as regards acidity produced in moorland waters, rendered the foregoing hypothesis almost, if not wholly, untenable.

2. *The oxidation of iron pyrites* resulting in the formation of sulphuric acid and ferrous sulphate. This explanation of the acidity of moorland waters has been ably advocated and merits careful consideration.

On one of the gathering grounds (Rochdale), which was made the subject of attentive study, there was found a disused mine containing rock very rich in iron pyrites. At one time, the water draining from this mine obtained access to the waterworks, and contaminated the supply to a serious extent. Although this is no longer the case, it was thought desirable to test samples of this water, as regards acidity and action on lead. The results of this examination have been fully considered in this report; the water was found to be extremely acid, and was also plumbo-solvent in character. Further, a filter constructed of rock obtained from the mine rendered neutral water, continuously filtered through it for a prolonged period, highly acid, and, when suitably diluted, plumbo-solvent as well. So that, unquestionably, iron pyrites is a possible source of the acidity of moorland waters. In this report numerous experiments have also been described in which iron pyrites was kept in contact with water for a long time, and was also mixed with peat; the mixed peat and pyrites were "treated" in a number of different ways. Thus, sometimes the peat mixed with iron pyrites was "weathered" for a long time, and then neutral water was slowly passed through it; at other times the mixture was left for a considerable time in contact with neutral water; yet again in other experiments, neutral water was continuously or intermittently filtered through a funnel containing the mixture of peat and pyrites. The experiments, as a whole, showed that neutral water brought under the conditions described above into relation with iron pyrites is apt to acquire acid properties.

Great difficulty was experienced in obtaining any reliable information as to the presence and, if present, the distribution of iron pyrites on the various gathering grounds. If present in the rock underlying the surface soil, the occurrence of acidity in moorland spring water obtained in the close vicinity might have been anticipated. But this has not been found to be the case, and, moreover, the ferruginous spring water on moorland gathering grounds was also observed to be neutral in reaction. Further, the water issuing from rock on moorland gathering grounds is, as compared with the huge bulk of acid water derived from the surface drainage of peat, very small in amount. It has been observed repeatedly on moorland gathering grounds that, when the surface water is at its minimum (dry weather flow), the water reaching the waterworks is least acid, and when at its maximum

(storm time), the maximum acidity is attained in the water collected at the waterworks. The worst moorland waters, as regards acidity, have always been found to be those in which the quantity of surface peaty water was at a maximum and the quantity of water which had passed over or through the rock at a minimum. Moreover, the prolonged series of experiments, in which peat removed from the gathering grounds has been shown to be capable of rendering acid a relatively large bulk of neutral water, the peat being either left in contact with the water or the water continuously or intermittently filtered through it, will hardly admit belief in any theory which does not involve the acceptance of peat as the substance concerned in the production of acid. It can hardly be supposed that iron pyrites has a universal distribution in the peat on moorland gathering grounds. There is difficulty, therefore, in accepting the oxidation of iron pyrites as the sole explanation of the acidity observed in moorland waters.

### 3. *The microphytic theory*, advanced by Mr Power in 1887.

In summarising the observations arising out of the inquiries made at Sheffield in connection with lead poisoning, traced by Dr. Sinclair White to moorland water supply, Mr. Power wrote as follows\* :—

“Phenomena such as these if observed in the biological laboratory in relation with the life processes of one or another microphyte would not be difficult of comprehension. The suggestion of them, therefore, in this connection will have raised suspicion whether the inscrutable behaviour of soft moorland waters in regard of the plumbo-solvent ability may not be related to the agency, direct or indirect, of low forms of organic life. So that the question would seem to be arising whether chemistry, which by itself has failed to afford satisfactory explanation of the plumbo-solvency of moorland water, may not get advantage by association of biology in the problem.”

In this report, it has been pointed out that moist peat is practically always acid in reaction, and that peat removed from the gathering grounds and brought into relation, in a variety of ways, with a relatively large quantity of neutral water has the power of rendering such water acid and plumbo-solvent in character. Further it has been shown that a mixture of micro-organisms obtained from peat, when introduced into a *sterile decoction made solely from peat*, not uncommonly renders the peat decoction acid and plumbo-solvent in character. Lastly, that two microbes (Peat bacteria O and Q) isolated from peat can, when separately added in pure culture to sterile peat decoction, produce the same effects, as regards acidity and plumbo-solvency, as are observed when a mixture of peat microbes is used for inoculation purposes.

Similar biological results were obtained when peaty water instead of peaty soil was used for experimental purposes; but it is probable that the acid-producing microbes in such water are derived from peat, and that a water, when it has left the peat, has completed its life history so far as acidity is concerned. In this connection it will be remembered that it has been shown that acid moorland waters (not fortified with peat decoction) tend to lose and never to gain acidity on keeping. Further, that acid moorland waters after neutralisation do not on keeping become appreciably acid again.

These results undoubtedly lend support to Mr. Power's theory—that the antecedent cause of the acidity of moorland waters is to be sought for in the life processes of low forms of organic life. These life

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\* Supplement to the 17th Annual Report of the Local Government Board.

processes, it is believed, are carried out in the substance of moist peat soil, the acid substances being manufactured *in situ* and washed into the waterworks with each successive rainfall.

Of other substances, found in the peat or underlying the peat, and which might be associated with acid production, mention has already been made. Deposits of iron (in the form of what is locally known as "iron ore," "bog iron ore," &c.) extracted from the peat or scraped from the marl underlying the peat have been made the subjects of experiment; so also have shale and sandstone rock underlying the peat. In all cases, the results, as regards acid production, have been practically negative.

There are many circumstances which, in connection with the antecedent cause of the acidity of moorland waters, still remain obscure. It would seem, however, that the most probable theory is that the acid is manufactured in the substance of the peat, and, further, that such acidity is produced (at all events, in part) by the vital activity of peat micro-organisms.

## SECTION IV.—GENERAL SUMMARY AND CONCLUSIONS.

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### I.—EROSION OF LEAD.

1. It was pointed out in Volume I. that there is a difference in kind of the action exercised by water on lead. The one kind of action (plumbo-solvency) is brought about by acidity of the water, and has been considered in great detail both in Volume I. and in the present report. The other kind of action (erosion), dealt with only incidentally in Volume I., is an inherent property of water containing dissolved air. All waters do not erode lead, because most waters contain substances which, when brought into contact with lead, coat the bright surface of the metal, thus preventing any further action taking place. Erosion may be described as the power possessed by some waters of acting, in the presence of dissolved air, on *bright* lead by eating away the surface of the metal. Some moorland waters are not culy acid and possessed of plumbo-solvent ability, but “erode” lead as well. But in the absence of associated acidity and plumbo-solvency, ability to erode lead appears to be of secondary importance. Erosive ability, *per se*, is not to be regarded, seemingly, as an intrinsically dangerous quality of a water unless under special conditions and in the presence of *bright* lead. The method of testing waters, as regards erosion of lead, is fully described in Section I. of this report. The following is a brief summary of the numerous experiments carried out in this connection :—

#### *Rain and Snow Water.*

2. Pure rain and snow water commonly erode lead in vigorous fashion.

#### *Distilled Water.*

3. Distilled water, if pure and neutral in reaction, is usually possessed of conspicuous erosive power.

4. The following substances or conditions do not seemingly influence, to any material extent, the erosive power of distilled water\* :—Shaking the water with one or other of the following substances and then filtering : silica, powdered flint, and powdered polarite; repeated filtration through limestone (in the laboratory); keeping for long periods in partially filled and unstoppered bottles or in bottles completely filled and stoppered; boiling, if followed by aeration; exhaustion of the dissolved gases, if followed by aeration; aspirating air through the water; saturation with hydrogen gas, if followed by aeration; Repeated distillation; presence or absence of light; [? addition of sodium and potassium nitrate and nitrite].

5. The following substances or conditions tend to increase the erosive power of distilled water\* :—Ammonium nitrate; Complete aeration; Prolonged contact; Free exposure of the surface of the liquid to the air.

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\* See note p. 421.

6. The following substances or conditions inhibit to a greater or less extent the erosive power of distilled water\* :—Anaerobic conditions ; Saturation of the water with pure hydrogen gas ; Saturation with pure oxygen gas ; Ammonium carbonate ; Sodium carbonate and sodium and calcium bicarbonates ; Sodium and calcium phosphates ; Magnesium and calcium sulphates ; Ammonium and sodium chlorides : “Coated” lead ; Hard limestone water ; Lime water (slight) ; Alloys of lead and tin ; Shaking with powdered chalk and limestone, followed by filtration.

7. Substances or conditions which delay, rather than prevent, the erosive power of distilled water\* :—Mineral acids and carbonic acid (in the strengths used in the experiments) ; Imperfect aeration.

#### *Moorland Waters.*

8. Acid moorland waters frequently erode *bright* lead, and if conspicuous for acidity are apt to possess most vigorous erosive power. Erosion does not seem to occur almost immediately, as in the case of distilled water, but only slowly ; the lead not uncommonly acquires an imperfect coat, which later tends to fall away in patches, leaving the surface of the metal exposed to the erosive action of the water.

9. Neutral or only feebly acid moorland waters usually display little or no appreciable erosive power ; but they are nearly always “near the possession” of erosive ability ; this may be proved by adding to them *bright* lead and renewing it one or more times, and thus, by exhausting the “plumbo-protective” substances present, a vigorous erosive action can be induced.

10. Such moorland *spring* waters as were tested were commonly free from erosive power, and, not uncommonly, possessed as well what may be termed a reserve of “plumbo-protective” ability.

11. The following substances or conditions either increase, diminish, or prevent, or do not materially affect the erosive power of moorland waters :—Storing acid moorland waters for long periods in partially filled and unstoppered bottles and the concentration of an acid moorland water by boiling did not prevent erosion from taking place. The use of alloys of lead and tin and “coated” lead were not altogether satisfactory as regards erosion. Sodium carbonate, especially if present in excess of the amount required exactly to neutralise the water, proved to be most efficacious in not only preventing the occurrence of erosion, but also in placing the water in a position remote from erosive ability.

Lime water appeared to be less efficacious in the latter respect. The addition of calcium bicarbonate, either in the form of artificially prepared calcium bicarbonate solution, or as a natural limestone water, or by saturating the water first with carbonic acid and then filtering through marble, was usually satisfactory, provided the bicarbonate was present in sufficient amount in the water. A series of experiments, in which acid moorland waters were filtered through limestone, polarite, asbestos, sand, flint and marble, seemed to show that polarite, asbestos, sand (river sand, sandstone sand, and “HCl treated” sea sand) and flint, and in some measure limestone, sea sand (untreated), and marble were not altogether satisfactory ; since either erosion was inhibited, not

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\* These remarks to be read subject to the amounts of materials employed and the conditions of experiment specified in the various tables.



prevented, or the water was left in a condition not far remote from the possession of erosive ability. Nevertheless, in some of the experiments, especially those with the sea sand, the results were good. Shaking acid moorland waters with silica ( $\text{SiO}_2$ ) did not leave them in a safe condition as regards erosion. Calcium and sodium phosphates had an inhibitory action, but sulphates and chlorides did not prevent erosion from taking place; nitrites and nitrates (especially ammonium nitrate) increased erosion. A series of experiments, in which the acid moorland waters were shaken with limestone, chalk, Iceland spar, marble, polarite and flint, showed that polarite and flint were unreliable to counteract erosive ability; but that the rest of the above-named substances, not only inhibited erosion, but usually placed the waters remote from the possession of the ability to erode lead.

Evaporating an acid moorland water to dryness, and dissolving the residue (with or without ignition) in its own distillate, gave a liquid possessed of greater erosive power than the moorland water itself.

#### *Natural Waters other than Rain or Moorland Waters.*

12. Natural waters, other than rain or moorland waters, commonly not only fail to erode lead, but are remote from the possession of this ability to do so, since they contain a reserve of "plumbo-protective" substances. This is specially the case with a hard limestone water.

#### *Remedial Measures.*

13. "Treatment" of water, whether on the waterworks or in the laboratory, is seldom quite satisfactory; because, although it frequently inhibits or even prevents appreciable erosion from taking place, yet the water is left in a condition not remote from the possession of conspicuous erosive ability. Sometimes, indeed, the treatment seems actually to render the water more prone to erode lead. But "treatment" with sodium carbonate, whether carried out at a waterworks (e.g., Wakefield Waterworks) or in the laboratory, if performed in such a way as to leave traces of this substance in the water (i.e., in slight excess of exact neutralisation), appears to place the water so treated in a condition remote from the possession of erosive ability. The experiments seem to indicate that, in practice, it might be cheaper to resort to a preliminary lime or combined lime and sand filtration treatment, thus correcting the acidity, plumbo-solvent ability, and gross erosive power, and then to supplement this treatment finally with the further addition of sodium carbonate in minimal amount, so as, by endowing it with a reserve of a "plumbo-protective" substance, to place the water in a condition remote from the possession of erosive ability. There would seem to be this difference between erosion and plumbo-solvency, namely, that any treatment of a neutralising sort, even if imperfectly carried out, always renders an acid moorland water, as regards plumbo-solvency, less dangerous than before; whereas, as regards erosive ability, insufficient treatment may produce no appreciable inhibition of erosion, and, if laboratory experiments are to be trusted, may even, in certain cases, render the partially treated water more prone than before to erode lead in vigorous fashion. Treatment of any kind, be it noted, must alter the composition of a water, and if the treatment be accompanied by filtration, the suspended matters being removed, it will tend, for good or ill, to modify the character of protective coating deposited by the treated water on the lead. This does not, of

course, cast any doubt as to the wisdom of "treating" acid moorland waters. It is imperative to correct the acidity, and thereby the plumbo-solvent ability, of moorland waters, since it is in this direction that the manifest danger lies. In most cases such treatment will inhibit, or prevent, erosion as well; but the treatment to obviate erosion should be thorough, and also should be of such a kind as to place the treated water in a condition remote from the possession of erosive ability.

Risk of a water acquiring ability to act on lead may, as was pointed out in Volume I., in great measure be guarded against by methods designed to exclude from the supply contributory waters which experience has shown to be conspicuously and uniformly acid, plumbo-solvent, or erosive in character; and also, by mechanical contrivances, to exclude access after prolonged drought to the supply of the "first washings" of peaty soil.

## II.—PLUMBO-SOLVENCY.

14. The correlation of acidity and lead-dissolving property in regard of moorland waters (correlation of acidity and plumbo-solvency and relation between amount of acidity and vigour of solvent action on lead) has been already dealt with in great detail in Volume I. The results set forth in the present report confirm those already recorded, and yield fresh information in a number of important directions, e.g., the effect of different kinds of "treatment" of moorland waters as regards acidity and plumbo-solvency. For details of the method of testing water, as regards plumbo-solvency, Volume I. must be consulted.

### *Rain and Snow Water.*

15. Rain and snow water are usually neutral and free from appreciable plumbo-solvent ability. Some samples of rain-water, however, collected on high gathering grounds, in the neighbourhood of large manufacturing towns, have been found to be possessed of some slight degree of acidity and lead-dissolving power.

### *Distilled Water.*

16. Pure distilled water is commonly neutral in reaction and free from definite plumbo-solvent powers. Some samples of distilled water, however, may be acid, and in these cases the water dissolves lead to an extent roughly corresponding with the degree of acidity. It was found that the *naturally* acid and plumbo-solvent samples of distilled water were rendered neutral and non-plumbo-solvent in character by boiling, aeration, neutralisation, or storing for some time in partially filled and unstoppered bottles.

### *Moorland Waters.*

17. As previously explained, the question of the correlation of acidity and lead-dissolving property and the broad parallelism between the amount of acidity and vigour of solvent action on lead was fully considered in Volume I.; and the confirmatory results set forth in the present report may be said to establish the matter as a fact. There remains for consideration the substances, conditions, or factors which tend to increase, modify, or remove the acidity and plumbo-solvent ability of moorland waters.

18. The following substances, conditions, or factors do not seem, with regard to moorland waters, to influence *materially* the question of acidity and plumbo-solvency, or at best can only be considered as of relative value:—Magnesium and calcium sulphates, sodium and ammonium chlorides, in the proportion of 0·1 per cent.; Storing moorland waters in partially filled and unstoppered bottles for long periods; Boiling (as regards some waters at all events); Aeration; Shaking with powdered flint, silica, and certain kinds of sand; Filtration through asbestos, coke, polarite, flint, and certain kinds of sand; “coated” lead.

19. The following substances, conditions, or factors seem to increase the plumbo-solvent ability of moorland waters:—Potassium sodium and ammonium nitrates (to some extent seemingly); Concentration by boiling (with some waters, at all events); [? temperature and duration of contact, within certain limits].

20. The following substances, conditions, or factors may remove the plumbo-solvent ability of moorland waters:—Ammonium and sodium carbonates, lime water, limestone water; Calcium and sodium phosphates, if present in amount sufficient to neutralise the acidity; Shaking with excess of powdered chalk, marble, Iceland spar, limestone, and certain kinds of sand, by neutralising the acidity; Filtration through Iceland spar, marble, limestone, chalk, and certain kinds of sand, by neutralising the acidity. [Potassium silicate and sodium nitrite inhibited plumbo-solvency, but the samples were alkaline in reaction and neutralised the acidity.]

21. The continuous passage of an acid moorland water through the same lead shot did not result in the water, at the close, dissolving less lead than in the earlier stages of the experiment.

22. The repeated filtration of the same sample of moorland water through the same lead shot did not result in the water dissolving more and more lead as the filtration was repeated again and again.

#### *Natural Waters other than Rain or Moorland Waters.*

23. No special experiments were carried out under this heading, for the reason that the investigation of the negative side of the question of plumbo-solvency was sufficiently covered by the examination of multiple samples of moorland spring waters and moorland *treated* waters. These results have already been set forth in Volume I.; and it only remains to say that the moorland spring water and the moorland *treated* (when the treatment was satisfactory) water, were always found to be neutral and free from appreciable solvent action on lead.

### III.—THE CAUSE OF THE ACIDITY OF MOORLAND WATERS.

#### *(a.) Chemical Experiments.*

24. If acid moorland waters be kept for some time in completely filled and stoppered bottles, there is either no loss or only a slight loss of their initial acidity. If the waters be kept in partially filled and unstoppered bottles, an appreciable loss of acidity usually occurs. Under neither set of conditions was any appreciable gain in initial acidity observed after prolonged storage.

25. Acid moorland waters do not, after neutralisation, re-develop acidity, although stored for considerable periods—(a) in stoppered

bottles with an air space, (b) in unstoppered bottles, and (c) in completely filled and stoppered bottles.

26. Boiling and aerating acid moorland waters sometimes has the effect of diminishing the amount of their acidity; but other waters, when concentrated by boiling, gain in acidity to an extent roughly corresponding to the degree of concentration of the water.

27. The addition, separately, to neutral distilled water of peat ash, sulphide of iron, iron deposits (obtained from peat or scraped from the marl underlying the peat), sandstone, and shale (underlying the peat), did not render the water appreciably acid. The addition of these substances to acid moorland waters did not lead (indeed, sometimes the reverse was the case) to any material gain in the initial acidity. But marcasite, and iron pyrites, had the effect of rendering neutral water acid.

28. Samples of water (drainings) obtained from a disused mine (rock rich in iron pyrites) on a moorland gathering ground were found to be acid and plumbo-solvent in character, but practically free from erosive ability. A laboratory filter was constructed of the broken rock (rich in iron pyrites) obtained from this mine, and neutral water was for several months continuously filtered through it. The filtrate was always found to be very acid, and, when suitably diluted with neutral distilled water, to dissolve lead to marked extent. There can be no doubt, therefore, that the oxidation of iron pyrites may be advanced as a possible antecedent cause of the acidity of some moorland waters. But it cannot well be accepted as the sole explanation of the acidity of moorland waters in general, unless it be assumed that iron pyrites has a universal distribution on moorland gathering grounds. Because, as will presently be pointed out, samples of peat obtained from many different gathering grounds, and subjected in the laboratory to conditions simulating as closely as possible the stagnation in, or filtration of rain through, the peat, which under natural conditions takes place, invariably conferred on the neutral distilled water, or rain-water brought into relation with it, acid and plumbo-solvent characters.

29. A relatively small quantity of peat can render acid and plumbo-solvent a large bulk of neutral and non-plumbo-solvent water, under the following conditions of experiment :—

- (a.) Peat left in contact with a large bulk of stagnant water.
- (b.) Water intermittently filtered through peat.
- (c.) Water continuously passed through peat, which is kept saturated with water.

It has been conclusively proved that one part of peat may be capable of rendering acid and plumbo-solvent more than one hundred parts of a neutral non-plumbo-solvent water.

30. Peat alone confers practically as much acidity, and plumbo-solvency, on neutral waters as peat mixed with sulphide of iron, powdered shale, or deposits of iron (obtained from the peat). But peat mixed with iron pyrites is apt to render water more acid, and plumbo-solvent, in character than peat by itself.

#### (b.) *Bacteriological Experiments.*

31. In 1893 it was observed that the moist peat soil tested *in situ* on the Bentham moorland gathering ground had practically always an acid reaction. The same was found to be the case with the peat tested

during the surveys of the chief moorland gathering grounds of Yorkshire and Lancashire. Further, it was found that acid moorland waters did not gain, but tended to lose their initial acidity on keeping, and, if first neutralised, did not redevelop acid. Again, rain-water draining from peat, or lying stagnant in hollows or depressions in the peat, was nearly always found to be acid in reaction; and the more peaty the water, the more acid was it usually found to be. Lastly, peat removed from the moorland, and brought into relation with neutral water in a variety of ways, but always in such a manner as to simulate natural conditions, was found to possess the power of rendering neutral water acid and plumbo-solvent in character. These observations led to a prolonged study of the bacteriology of peat, and to the use as a nutrient medium of a decoction made solely from peat.

32. It was found that certain acid moorland waters, with and without the inhibition of bacterial growth by means of alcohol, did not gain in acidity on keeping; but if the nutritive value of the waters was increased by the addition of sterile peat decoction, there usually occurred in the mixture containing no alcohol an increase of acidity.

33. Similarly it was found that the addition to sterile peat decoction of acid moorland waters in minute amount, not uncommonly led in the decoction to bacterial growth and development of acidity. The acid-producing bacteria in the water were derived, it would seem, from the peat:

34. A mixture of peat microbes added to sterile peat decoction likewise not uncommonly resulted in the production of acid.

35. Isolated in pure culture, these peat microbes for the most part failed to render sterile peat decoction appreciably acid.

36. A minority, two in number (Peat bacterium O and Peat bacterium Q), were found to be capable, when introduced into sterile peat decoction, of rendering the liquid acid and plumbo-solvent in character.

37. From the results detailed in this report it is impossible to ignore the fact that peat divorced from the moorland, and brought into relation with neutral water can, under laboratory conditions of experiments, be brought to yield to such water qualities which, as regards acidity and plumbo-solvency, are undistinguishable from the similar attributes characteristic of natural peaty waters.

38. It may therefore be taken as established that the chief antecedent cause of the acidity of moorland waters is to be sought for in the peat.

39. It is a difficult problem to determine by what process, chemical or biological, the peat yields up its potential acidity to water brought into sustained contact with it, or flowing over it or through it.

40. But the facts recorded in this report, as regards the power possessed by certain peat microbes to render a sterile neutral decoction made solely from peat both acid and plumbo-solvent in character, lend support to Mr. Power's forecast of 1887, namely, that the inscrutable behaviour of soft moorland waters in regard of plumbo-solvent ability may be related to the agency, direct or indirect, of low forms of organic life.

41. In conclusion, it may be said that, while in moorland waters the cause of plumbo-solvency is to be traced to the presence of acid in the water, and the source of the acid to contact with peat, the antecedent cause of the acidity seems to be associated, at all events in part, with the presence of acid-producing bacteria in the peat itself.

IV.—SOME OF THE CONCLUSIONS IN VOLUME I. WHICH, FOR THE SAKE OF COMPLETENESS, MAY BE INCORPORATED WITH THE FOREGOING.

42. The history of epidemics of lead poisoning due to water supply, at all events in the North of England, clearly shows that the towns which have suffered in the past derived their water supply from moorland sources. In some cases we know that the water was acid, and in others there was every reason to infer that the water was in a similar condition, since the physical circumstances of the gathering ground were the same.

For example, Sheffield has a "high" and a "low" level supply. Lead poisoning occurred chiefly, if not entirely, amongst the consumers of the high-level supply. This water was proved to be acid, whereas the low-level supply was found to be neutral. The high-level water was treated with lime, which neutralised the acidity, and lead poisoning was no longer observed. Both supplies were derived from upland gathering grounds; but the high-level supply was rich in acid peaty water, and contained very little spring water, whereas the low-level supply contained a much larger proportion of neutral spring water and very little peaty water.

Similarly, Mossley suffered from lead poisoning in 1893. Dr. Cope-  
man, in his report to the Board, showed conclusively that lead poisoning was prevalent only in those districts supplied with acid water from Lower Swineshaw Reservoir, and that when the neutral water from Brushes Reservoir and from the Greenfield Valley (springs) was supplied to the inhabitants, there was no lead poisoning. Mossley was kept under observation for a considerable period. Not only was the water in Lower Swineshaw Reservoir found to be acid, but the water as delivered to Mossley was also found to be uniformly acid and possessed of plumbo-solvent ability. In December 1894, "treatment" of the water was commenced, lime being added to the water in Lower Swineshaw Reservoir. Gradually the effect of the "treatment" showed itself in Mossley, and eventually the water became practically neutral and free from plumbo solvency. Coincident with this change in the quality of the water, lead-poisoning was no longer complained of. On September 25, 1895, a visit was paid to Mossley, and the water in Lower Swineshaw Reservoir tested. It was found to be practically neutral and free from plumbo-solvent ability.

43. Moorland gathering grounds are usually rich in peat. The amount of peat varies greatly on different gathering grounds, both superficially and in depth.

44. Moist peat has been found to be invariably acid in reaction.

45. The water draining from peat is always acid, and acid peaty water dissolves lead. The amount of acidity depends chiefly on the amount of peat and the length of time during which the water has been in contact with it.

46. The degree of plumbo-solvency of a water is chiefly governed by the amount of its acidity.

47. Moorland spring water is neutral and often possessed of slight acid-neutralising ability. In virtue of this property, spring water is commonly capable of neutralising a certain proportion of acid peaty water.

48. Neutral water does not dissolve lead to any appreciable extent.

49. Moorland waters, as received into storage or service reservoirs, usually contain a mixture in variable amount of acid peaty water and

neutral spring water. The reaction of the "mixed" water, at any given time, is determined by the relative amount of peaty water and the degree of its acidity, on the one hand, and by the relative amount of spring water and the degree of its acid neutralising ability on the other.

50. During dry weather, and especially at the end of a period of dry weather, the water in moorland streams is almost invariably neutral and free from plumbo-solvent ability.

51. During dry weather the water in moorland streams is chiefly composed of spring water; during wet weather the water consists chiefly of surface water draining from peaty soil.

52. During storms the water in moorland streams is usually very acid and acts strongly on lead. Especially is this the case when the wet weather succeeds a period of drought, as then the streams contain the "first washings" of the peat.

53. On most moorland gathering grounds there are areas (particularly on the higher and flatter portions of the gathering grounds) where the rain stagnates in peaty, boggy, and marshy places. Such water has always been found to be acid in reaction.

54. On many gathering grounds a layer of impervious marl underlies the beds of peat. This prevents the escape of the rain in a downward direction, and so the water is "held" in the peat, or escapes only by slow lateral percolation. Thus the peat is always moist, and each successive rainfall washes out of the peat substances formed during the more or less prolonged contact of the water with the peat, which have rendered the water considerably acid.

55. The "dry weather" flow on most moorland gathering grounds is very small, and is usually quite inadequate to meet the requirements of the town or towns supplied with water.

56. In such cases, during a period of drought, the water in the compounding reservoirs sinks rapidly to a very low level.

57. When heavy rain comes after drought, millions of gallons of acid peaty water are frequently allowed to enter the water works. Indeed the storage reservoirs are constructed for this very purpose, namely, to store for future consumption a vast bulk of "storm" water, the ordinary flow of the streams being far too small to keep the reservoirs at their proper level.

58. Thus it not infrequently happens that, during dry weather, a reservoir water is strongly acid, while all or nearly all the "inlet" streams contain neutral water. In storm time, however, these streams contain, not only acid water, but the water in them is usually more acid than the water in the reservoir itself.

59. Although large quantities of peat are frequently washed into reservoirs, and although the beds of some reservoirs are largely composed of peat, the acidity of the water in moorland reservoirs is not to be traced, or only in small measure, to this circumstance, but to the ingress of large quantities of acid water during storms. No doubt, however, the peat washed into the reservoirs and the peat in the bed of the reservoirs assists in "keeping" the water acid. Laboratory experiments seem to prove that an acid peaty water stored out of contact with peat does not increase in acidity, but tends to lose some of its original acidity.

60. It would appear, as a practical outcome of this inquiry, that the circumstances of every supply of moorland origin should be considered with reference to the factors of plumbo-solvency which exist upon it, and in this report endeavour has been made to make clear the nature of these factors and their relative importance. It is advisable in the case of existing works to test, not only in the reservoirs and main streams, but also in the tributary streams and subsidiary "feeders," during different seasons of the year, and under ordinary and extraordinary conditions of the rainfall, in order to arrive at a satisfactory conclusion as to the liability of the supply in general, and of its constituent waters, to acquire plumbo-solvent ability. Study of this sort affords the most satisfactory means of determining how best to apply the remedy, or combination of remedies, needed in the particular instance.

In the case of proposed new waterworks, this inquiry indicates the necessity of a careful survey of the physical characters of the gathering grounds, as well as of ascertaining the proportion of spring water to surface water at different times of the year and under different conditions of rainfall, and of testing the quality of the spring water and its power of neutralising acid, and the quality of the surface water, especially during wet weather and sudden storms following a period of drought.



# ADDENDUM A.

In the following table (Table CLX.) the quality of the water, as regards acidity and action on lead, supplied to various sanitary districts in Yorkshire is shown:—

TABLE CLX.

Showing the QUALITY of the WATER (as regards ACIDITY and ACTION on LEAD) supplied to various SANITARY DISTRICTS in YORKSHIRE.  
[The Samples of Water were usually taken from the Main, and in the few instances in which the WATER was taken from a House Tap the Water was allowed to run to Waste for some time before Collection of the Sample.]

Experiment.	Date.	Name of Sanitary District.	Public Water Service supplying Districts.		Hardness CaCO <sub>3</sub> Parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ N <sub>2</sub> CO <sub>3</sub> required to neutralise the Water.	Re-action with Lac-mold.	Plumbo-solvency. Results stated as Parts per 100,000. Tested by Upward Filtration through 50 c.c. Lead Shot at the Rate of 3 mins. per 50 c.c.					"Erosion" Experiments.	
			Names.	Sources.				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Aver- age.
1	Oct. 4 1894.	Birkenhaw U.S.D.	Bradford Corporation Water-works (high level service). (Page 108, Vol. I.)	Moorland, Thornton Moor.	6.3	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. of the water in test tube with bright sheet lead, 1 x 1".  (b.) Same as (a). (c.) 5 c.c. of the water, and 5 c.c. XXX distilled water in test tube with bright sheet lead, 1 x 1". October 5th, 1894. Distinct action in (c); none in (a), (b); lead renewed in (b). October 9th. Action renewed. October 14th. Action new in (b). October 19th, 1894. Still no action in (a).
2	Oct. 4 1894.	Birstal U.S.D.	Bradford Corporation Water-works (high level service).	Moorland, Thornton Moor.	6.3	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) 10 c.c. of the water in test tube with bright sheet lead, 1 x 1". (b.) Same as (a). (c.) 5 c.c. of the water, and 5 c.c. XXX distilled water in test tube with bright sheet lead, 1 x 1".

3	Oct. 12, 1894.	Clayton U.S.D.	Bradford Corporation Water-works (high level service).	Moorland, Thornton Moor.	"Treated" with chalk and then filtered.	6.3	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	<p>October 5th, 1894. Distinct action in (a); none in (a), (b); lead renewed in (b).</p> <p>October 6th. Lead renewed again in (b).</p> <p>October 7th. Action now in (b).</p> <p>October 18th. Still no action in (a).</p> <p>(a.) 10 c.c. of the water in test tube with bright sheet lead, 1x4".</p> <p>(b.) Same as (a).</p> <p>(c.) 5 c.c. of the water, and 5 c.c. XXX distilled water, in test tube with bright sheet lead, 1x4".</p> <p>October 13th, 1894. No action in (a), (b), (c). Lead renewed in (b) October 13th and 14th.</p> <p>October 29th. Still no action (a), (b), (c).</p>
4A	Oct. 25, 1894.	Mirfield U.S.D.	Huddersfield Corporation Water-works. (Page 138, Vol. I.)	Moorland, Blackmoor-foot.	Not "treated."	4.5	0.3	Acid	0.2	0.4	0.5	0.6	0.7	0.46	<p>(a.) 10 c.c. of the water in test tube with bright sheet lead, 1x4".</p> <p>(b.) Same as (a).</p> <p>(c.) 5 c.c. of the water, and 5 c.c. XXX distilled water, in test tube with bright sheet lead, 1x4".</p> <p>October 28th. Distinct action in (c); none in (a), (b); lead renewed in (b).</p> <p>October 27th. Action now in (b) and none in (a). Amount of lead in (a), (b), (c), estimated and found to be 1, 10, 20, respectively, parts per 100,000.</p>

TABLE CLX.—*continued.*

Experiment.	Date.	Name of Sanitary District.	Public Water Service supplying Districts.			Hardness CaCO <sub>3</sub> per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ N <sub>2</sub> CO <sub>3</sub> required to neutralise 100 c.c. of the Water.	Re-action with Lac-moid.	Plumbo-solvency. Results stated as Parts per 100,000. Tested by Upward Filtration through 50 c.c. Lead Shot at the Rate of 3 mins. per 50 c.c.					"Erosion" Experiments.	
			Names.	Source.	"Treated," or otherwise.				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
4b	Feb. 7, 1893.	Mirfield U.S.D.	Huddersfield Corporation Water-works.	Moorland, Blackmoor-foot.	Not "treated."	5.5	0.36	Acid	0.1	0.2	0.3	0.3	0.4	0.26	(a.) Same as (a), (b), (c), experiment 4a. (b.) } (c.) } February 8th, 1893. Distinct action in (c); none in (a), (b); lead renewed in (b). February 9th. Action now in (b), and none in (a). February 11th, 1893. Amount of lead in (a), (b), (c), estimated and found to be 1.5, 10.0, and 15.0 respectively, parts per 100,000.
4c	Apr. 18, 1893.	Mirfield U.S.D.	Huddersfield Corporation Water-works.	Moorland, Blackmoor-foot.	Not "treated."	6.0	0.42	Acid	0.2	0.3	0.4	0.4	0.5	0.36	(a.) Same as (a), (b), (c), experiment 4a. (b.) } (c.) } April 18th. Distinct action in (c); none in (a), (b); lead renewed in (b). April 20th. Action now distinct in (b); still none in (a). April 22nd. Amount of lead in (a), (b), (c), estimated and found to be 1.5, 10.0, 10.0 respectively, parts per 100,000.
5	Oct. 27, 1894.	Southowram U.S.D.	Hallifax Corporation Water-works. (Page 132, Vol. I.)	Moorland	Not "treated."	2.8	Neutral	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) Same as in previous experiments. (b.) } (c.) } October 28th. Distinct action in (c); none in (a), (b); lead renewed in (b).

6	Oct. 29, 1894.	Northowram U.S.D.	Halifax Corporation Water- works.	Moorland	Not "treated."	3.5	Trace	Acid very faint.	0.0	0.0	0.1	0.2	0.2	0.1	0.1	October 29th. Still no action in (a), (b), or (c). October 30th. Action now distinct in (b). November 3rd. Still no action in (a). (a.) } Same as in previous experi- (b.) } ments. (c.) } October 29th. Slight action in (c); none in (a), (b); lead renewed in (b). October 31st. Still no action in (a); action, however, distinct in (b). November 5th, 1894. Still no action in (a).
7A	Jan. 30, 1896.	Wakefield R.S.D. (part of).	Halifax Corporation Water- works.	Moorland	Not "treated."	4.2	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experi- (b.) } ments. (c.) } January 31st and February 1st. Lead renewed in (b), as no action. February 4th, 1896. No action in (a), (b), and only a slight action in (c). Amount of lead in (a), (b), (c), estimated and found to be traces, traces, 2.5, respectively, parts per 100,000.
7B	Feb. 23, 1896.	Wakefield R.S.D. (part of).	Halifax Corporation Water- works.	Moorland	Not "treated."	5.2	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experi- (b.) } ments. (c.) } February 23rd and 24th. Lead renewed in (b). Still no action in (a), (b), and only slight action in (c). Amount of lead in (a), (b), (c) estimated and found to be traces, 1.0, 3.0, respectively, parts per 100,000.

TABLE CLX.—continued.

Experiment.	Date.	Name of Sanitary District.	Public Water Service supplying Districts.			Hardness $\text{CaCO}_3$ Parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10} \text{N}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Reaction with Lead-mold.	Plumbo-solvency. Results stated as Parts per 100,000. Tested by Upward Filtration through 50 c.c. Lead Shot at the Rate of 3 mins. per 50 c.c.						"Erosion" Experiments.
			Names.	Source.	"Treated," or otherwise.				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
7c	Mar. 30, 1896.	Wakefield R.S.D. (part of).	Halifax Corporation Water-works.	Moorland	Not "treated."	5.3	Nil.	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experiments. (b.) } (c.) } March 31st and April 1st, 1896. Lead renewed in (b). April 3rd. Still no action in (a); very slight in (c); distinct in (b). Amount of lead in (a), (b), (c), estimated and found to be traces, 10.0, 1.0, respectively, parts per 100,000.
8	Feb. 8, 1896.	Hunale (part of) R.S.D.	Halifax Corporation Water-works.	Moorland	Not "treated."	5.5	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experiments. (b.) } (c.) } February 9th and 11th. Lead renewed in (b). February 13th. No apparent action in (a), (c); distinct in (b). Amount of lead in (a), (b), (c), estimated, and found to be traces, 10.0, 1.0, respectively, parts per 100,000.
9	Apr. 19, 1896.	Thornhill U.S.D.	Halifax Corporation Water-works.	Moorland	Not "treated."	5.0	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experiments. (b.) } (c.) } April 20th and 31st. Lead renewed in (b).

10	Apr. 19, 1896.	Hebden Bridge U.S.D.	Halifax Corporation Water- works.	Moorland	Not "treated."	6.7	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	April 23rd. No action in (a), slight in (c), and distinct in (b). Amount of lead in (a), (b), (c), estimated and found to be traces, 10.0, 1.0, respectively, parts per 100,000.  (a.) } Same as in previous experi- (b.) } ments. (c.) } April 20th and 21st. Lead renewed in (b). April 23rd. No action (a), (b), (c). Amount of lead in (a), (b), (c), estimated and found to be traces, traces, traces, respectively.
11	May 14, 1893.	Brickhouse U.S.D.	Halifax Corporation Water- works.	Moorland	Not "treated."	4.9	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experi- (b.) } ments. (c.) } May 15th. Lead renewed in (b). May 16th. Slight action in (b), so lead not renewed. May 20th. No action in (a); slight action in (c), (c). Lead in (a), (b), (c), estimated and found to be traces, 5.0, 8.0, respectively, parts per 100,000.
12	Nov. 2, 1894.	Whitwood U.S.D.	Wakefield Corporation Water- works. (Page 189, Vol. I.)	Rishworth Moor.	Treated with carbonate of soda.	2.8	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experi- (b.) } ments. (c.) } November 3. Distinct action in (c); none in (a), (b). Lead renewed in (b). November 4th. Lead again renewed in (b). November 10th. Still no action in (a), (b).

TABLE CLX.—continued.

Experiment.	Date.	Name of Sanitary District.	Public Water Service supplying Districts.			Hardness $\text{CaCO}_3$ 10 Parts per 100,000.	Acidity in Terms of c.c. $\frac{1}{10}$ $\text{Na}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Reaction with Lac mold.	Plumbo-solveney. Results stated as Parts per 100,000. Tested by Upward Filtration through 50 c.c. Lead Shot at the Rate of 3 min. per 50 c.c.					"Erosion" Experiments.	
			Names.	Sources.	"Treated," or otherwise.				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.		Average.
13	Nov. 5, 1894.	Featherstone U.S.D.	Wakefield Corporation Water-works.	Rishworth Moor.	Treated with carbonate of soda.	3·1	Nil	Neutral	0·0	0·0	0·0	0·0	0·0	0·0	(a.) } Same as in previous experiments. (b.) } (c.) } November 6th. Distinct action in (c) ; none in (a), (b). Lead renewed in (b). Lead again renewed in (b). November 7th. Lead renewed in (b). November 13th. Still no action in (a), (b).
14	Jan. 18, 1896.	Normanton U.S.D.	Wakefield Corporation Water-works.	Rishworth Moor.	Treated with carbonate of soda.	3·9	Nil	Neutral	0·0	0·0	0·0	0·0	0·0	0·0	(a.) } Same as in previous experiments. (b.) } (c.) } January 19th. Distinct action in (c) ; none in (a), (b). Lead renewed in (b), January 19th and 20th. January 26th. Still no action in (a), (b). Lead in (a), (b), (c), estimated and found to be traces, traces, 15·0, respectively, parts per 100,000.
15	Jan. 28, 1896.	Tadcaster E.S.D. (part of).	Wakefield Corporation Water-works.	Rishworth Moor.	Treated with carbonate of soda.	3·5	Nil	Neutral	0·0	0·0	0·0	0·0	0·0	0·0	(a.) } Same as in previous experiments. (b.) } (c.) } January 29th. Distinct action in (c) ; none in (a), (b). Lead renewed in (b) January 29th and 30th.

16	Jan. 29, 1896.	Alkots U.S.D.	Wakefield Corporation Water- works.	Rishworth Moor.	Treated with carbonate of soda.	2.9	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	February 4th. Still no action in (a), (b). Lead in (a), (b), (c), estimated and found to be traces, traces, 80.0, respectively, parts per 100,000.
17A	Jan. 30, 1896.	Wakefield R.S.D. (part of).	Wakefield Corporation Water- works.	Rishworth Moor.	Not "treated."	4.7	0.6	Acid	1.0	2.0	2.4	2.4	2.04	(a.) } Same as in previous experi- (b.) } (c.) } ments. January 31st and February 1st. Lead renewed in (b). February 4th. No action (a), (b), (c). Lead in (a), (b), (c), estimated and found to be traces, traces, traces, respec- tively.
*17B	Feb. 22, 1896.	Wakefield R.S.D. (part of).	Wakefield Corporation Water- works.	Rishworth Moor.	Not "treated."	4.3	0.6	Acid	0.8	1.2	1.4	1.4	1.24	(a.) } Same as in previous experi- (b.) } (c.) } ments. February 23rd. Lead renewed in (b). February 27th. Action in (a), (b), (c). Lead in (a), (b), (c), estimated and found to be 15.0, 15.0, 15.0, respectively, parts per 100,000.



TABLE CLX.—continued.

Experiment.	Date.	Name of Sanitary District.	Public Water Service supplying Districts.		H. rd-ness $\text{CaCO}_3$ 10 Parts per 100,000.	Acidity in Terms of c.c. $\text{N}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Re-action with Lac-moid.	Plumbo-solvency. Results stated as Parts per 100,000. Tested by Upward Filtration through 50 c.c. Lead Shot at the Rate of 3 mins. per 50 c.c.					"Erosion" Experiments.	
			Names.	Source.				"Treated" or otherwise.	1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.		5th 50 c.c.
18A	Jan. 30, 1895.	Wakefield R.S.D. (part of).	Wakefield Corporation Water-works.	Rishworth Moor.	Treated with carbonate of soda.	2.8	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	(a.) } Same as in previous experiments. (b.) } (c.) } January 31st and February 1st. Lead renewed in (b). February 4th. No action (a), (b), (c). Lead in (a), (b), (c) estimated and found to be traces, traces, traces, respectively.
18B	Feb. 22, 1895.	Wakefield R.S.D. (part of).	Wakefield Corporation Water-works.	Rishworth Moor.	Treated with carbonate of soda.	2.9	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } February 23rd and 24th. Lead renewed in (b). No apparent action in (a), (b), (c). Lead in (a), (b), (c) estimated and found to be traces, traces, traces, respectively.
18C	Mar. 30, 1895.	Wakefield R.S.D. (part of).	Wakefield Corporation Water-works.	Rishworth Moor.	Treated with carbonate of soda.	4.9	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } March 31st and April 1st. Lead renewed in (b). No apparent action in (a), (b), (c). On testing, only traces of lead found in (a), (b), (c).

19	Nov. 9, 1894.	Ossett U.S.D.	Dewsbury and Heck- mondwike Water Board. (Page 127, Vol. I.)	Moorland, Dunford Bridge.	"Not treated."	3.9	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } November 10th and 11th. Lead renewed in (b). November 12th. Distinct action in (b); (c) : none in (a). November 30th. Same remarks.
20	Feb. 7, 1896.	Dewsbury U.S.D.	Dewsbury and Heck- mondwike Water Board.	Moorland, Dunford Bridge.	"Not treated."	4.3	Traces acid.	Traces acid.	0.0	0.06	0.1	0.1	0.07	(a.) } As in previous experiments. (b.) } (c.) } February 8th. Lead renewed in (b). February 9th. Action in (b). February 11th. Still no action in (a); distinct; none in (a). February 11th. Still no action in (a). Lead in (a), (b), (c), estimated and found to be traces, 18.0, 20.0, respectively, parts per 100,000.
21	Mar. 6, 1896.	Skelmanthorpe U.S.D.	Dewsbury and Heck- mondwike Water Board.	Moorland, Dunford Bridge.	"Not treated."	4.6	Traces acid.	Traces acid.	0.0	0.05	0.1	0.1	0.07	(a.) } As in previous experiments. (b.) } (c.) } March 7th. Lead renewed in (b). March 8th. Action distinct in (b); none visible in (a), (c). March 11th. Lead in (a), (b), (c), estimated and found to be 1.0, 18.0, 1.0, respectively, parts per 100,000.
22	Nov. 17, 1894.	Monk Bretton U.S.D.	Barnley Corporation Water works. (Page 84, Vol. I.)	Moorland, Incehew- worth.	Filtred	6.7	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } November 19th. Lead renewed in (b). November 30th. No action in (a), (c); but action in (b). November 28th. Distinct action in (b), still none in (a), (c).

TABLE CLX.—continued.

Experiment.	Date.	Name of Sanitary District.	Public Water Service supplying Districts.			Hardness of $\text{CaCO}_3$ Parts per 100,000.	Acidity in Terms of c.c. of $\text{N}_2\text{CO}_3$ required to neutralise 100 c.c. of the Water.	Reaction with Lead-mold.	Plumbo-solvency. Results stated as Parts per 100,000. Tested by Upward Filtration through 50 c.c. Lead Shot at the Rate of 3 mins. per 50 c.c.						"Erosion" Experiments.
			Names.	Source.	"Treated" or otherwise.				1st 50 c.c.	2nd 50 c.c.	3rd 50 c.c.	4th 50 c.c.	5th 50 c.c.	Average.	
23	Nov. 19, 1894.	Dodsworth U.S.D.	Barnsley Corporation Water-works.	Moorland, Ingbirchworth.	Filtered	6.7	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } November 20th. Lead renewed in (b). November 21st. No action in (a), but distinct action in (b), (c). November 28th. Still no action in (a).
24	Dec. 6, 1894.	Handsworth U.S.D.	Sheffield Corporation Water-works. (Page 178, Vol. I.)	Moorland (high level).	Treated with chalk.	4.6	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } December 7th. Action visible in (a), (b), (c). December 8th. Lead in (a), (b), (c), estimated and found to be 7.6, 8.0, 13.6, respectively, parts per 100,000.
25	Mar. 14, 1896.	Worley U.S.D. 1. District.	Sheffield Corporation Water-works.	Moorland (high level).	Treated with chalk.	5.9	Nil	Neutral	0.0	0.0	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } March 18th. Lead renewed in (b). March 18th. No action in (a); distinct action in (b), (c). Lead in (a), (b), (c), estimated and found to be traces, 10.0, 18.0, respectively, parts per 100,000.

26	Jan. 24, 1896.	Wharfedale R.S.D., Menston.	Menston Water- works.	Springs	Not "treated."	19.6	Nil	Neutral	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } January 28th and 26th. Lead renewed in (b). February 2nd and 1896. No action visible (a), (b), (c). On testing, only traces of lead found in (a), (b), (c).
27	Jan. 24, 1896.	Wharfedale R.S.D., Esholt.	Esholt Water- works.	Springs	Not "treated."	19.3	Nil	Neutral	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } January 28th and 26th. Lead renewed in (b). February 2nd. No action visible in (a), (b), (c). On testing only faint traces of lead found in (a), (b), (c).
28	Jan. 28, 1896.	Tadcaster R.S.D., (part of).	Leeds Corporation Water- works. (Page 149, Vol. I.)	Moorland	Filtered	5.6	Nil	Neutral	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } January 28th and 30th. Lead renewed in (b). February 4th. No action visible in (a), (b), (c). Lead in (a), (b), (c), estimated and found to be 0.6, 0.8, 1.0, respectively, parts per 100,000.
29	Feb. 8, 1896.	Hunslet R.S.D., (part of).	Leeds Corporation Water- works.	Moorland	Filtered	6.8	Nil	Neutral	0.0	0.0	0.0	0.0	(a.) } As in previous experiments. (b.) } (c.) } February 9th and 11th. Lead renewed in (b). February 18th. No action visible in (a), (b), (c). On testing only traces of lead found in (a), (b), (c).
30	June 5, 1896.	Todmorden U.S.D.	Todmorden Water- works Company.	Moorland	Not "treated."	5.0	0.45	Acid	0.15	0.25	0.35	0.3	(a.) } As in previous experiments. (b.) } (c.) } Experiment failed.

The foregoing table, as it deals with a side of the question not previously considered, has been placed in Addendum to the report. In nearly all the experiments carried out during the investigation,\* the moorland waters were obtained from near their source, in order to avoid the possibility of modification due to delay in transmission, passage through pipes, &c. In the series under consideration, the water was collected in the condition in which it was being supplied to the consumers.

The waters were tested, as regards hardness, acidity, plumbo-solvency, and erosive ability.

Samples of water were obtained from 30 different sanitary districts, which were supplied from 11 different waterworks. Of these Mirfield U.S.D. (Huddersfield Corporation Waterworks), Wakefield R.S.D. (the part supplied with *untreated* Wakefield Water), and Todmorden U.S.D. (Todmorden Waterworks), were being supplied with acid and plumbo-solvent water. Northowram U.S.D. (Halifax Waterworks), Dewsbury U.S.D. (Dewsbury and Heckmondwike Waterworks), and Skelmanthorpe U.S.D. (Dewsbury and Heckmondwike Waterworks), were also receiving waters yielding positive results as regards acidity and action on lead. But in their case the acidity and plumbo-solvent ability were not nearly so well marked as in the case of Mirfield, Wakefield (part of R.S.D.), and Todmorden. The rest of the samples yielded negative results as regards acidity and plumbo-solvency. It is worth noting that the rural sanitary district of Wakefield was being supplied with three different kinds of water, namely, Halifax Waterworks (neutral and non-plumbo-solvent), Wakefield Waterworks *untreated* water (acid and plumbo-solvent), and Wakefield Waterworks *treated* water (neutral and non-plumbo-solvent).

As regards erosion, Wakefield R.S.D. (the part supplied with Wakefield *untreated* water) and Handsworth U.S.D. (Sheffield High Level *treated* water) were being supplied with water possessed of erosive ability. The Sheffield water is *treated* with chalk, and is rendered thereby neutral and non-plumbo-solvent in character. Seemingly, however, the treatment was not entirely satisfactory as regards arresting erosion of *bright* lead. It has already been pointed out, in this report, that while it is easy to render an acid and plumbo-solvent water neutral and non-plumbo-solvent in character, it is difficult to treat the water in such a manner as to place it in a position remote from the possession of erosive ability.

The rest of the waters were practically non-erosive in character; but most of them were near the possession of this ability, as was proved by exhausting the plumbo-protective substances present in them by renewal one or more times of the lead or by dilution of the water with a distilled water possessed of erosive power. Such procedure was usually sufficient to induce vigorous erosion. This, however, was not always the case; certain waters might be described as remote from the possession of erosive ability.

Although most of the waters were seemingly non-plumbo-solvent and non-erosive in character, it is by no means improbable that many of them were, so to speak, on the border line as regards possession of both solvent and erosive action on lead; so that under certain circumstances, e.g., a specially long lead service pipe, danger might arise from lead poisoning, particularly among persons showing any peculiar susceptibility to the deleterious influence of this metal, or those in the habit of drinking the water after it had been standing in the pipes over night. Here, as elsewhere in the report, statements as to water being non-plumbo-solvent or non-erosive in character must be interpreted in a relative sense, and as founded on the results of artificially contrived laboratory conditions of experiment. "*Safety, as regards inability to act on lead, under any conditions, in the case of a water yielding negative results with the tests employed, is therefore to be regarded as of relative, not necessarily of absolute, value.*"

It remains to be noted that in some of the districts above referred to, lead service pipes are not in use.

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\* This, however, was not always the case, as, for example, in many of the experiments with Mossley water.

## ADDENDUM B.

### THE QUESTION OF STANDARDS.

It is impossible to leave, without touching on the question of standards, the subject of lead poisoning by moorland waters. Fixed standards are apt to be open to objection; nevertheless, the moderate standards suggested will, it is hoped, be found of practical utility.

**Reaction.**—From the experience gained during 1893–98, in Yorkshire and Lancashire, it may be laid down as an established fact that a moorland water which gives an acid reaction with lacmoid solution will dissolve lead to a quite appreciable (and, therefore, probably dangerous) extent. Conversely, a moorland water which gives a neutral reaction with this indicator is practically “safe,” so far as appreciable solvent action on lead is concerned. The standard suggested is thus a very simple one, namely, that the water should give a neutral reaction with lacmoid solution of *ascertained activity*.

**Plumbo-solvency.**—This should be tested by upward filtration of the water through a glass tube (about  $\frac{1}{4}$  inch diameter and 2 feet long, tapered at the lower end and fitted above with a rubber bung and outflow tube). The tube should contain 50 c.c. (by measure) of specially prepared (i.e., free from hardening materials) lead shot; the water should be filtered through at the rate of 50 c.c. per 3 minutes. The simple apparatus used for this purpose is illustrated and described in Volume I. (pages 67 and 68 and Diagram A). After 200 c.c. of water have passed through the shot, the next 50 c.c. of filtrate are collected in a Nessler cylinder, and tested with sulphuretted hydrogen or ammonium sulphide solution. It is convenient to compare (a) the filtrate with (b) 50 c.c. of the unfiltered water (instead of with distilled water) and also with (c) 50 c.c. of the unfiltered water to which one to three drops of standard lead acetate solution (of such a strength that 1 c.c. is equivalent to 1 mgrm. of lead) have been added. After the addition of ammonium sulphide solution, the filtrate (a) should not show any more brown coloration than the unfiltered water, (b) and certainly less than the unfiltered water (c) containing one to three drops of lead acetate solution. As many moorland waters contain traces of iron, the water to be tested may, before adding the ammonium sulphide solution, be acidified with hydrochloric acid; but, in practice, the value of this precaution has not always been apparent. If on testing the filtrate with ammonium sulphide solution an appreciable brown coloration develops, then the amount of lead in solution must be estimated by colour-titration in the usual manner.

The standard here suggested is that, after filtering the water to be tested through the lead shot, as above described, the filtrate should either give no more coloration with ammonium sulphide solution than the unfiltered water, or at all events less than the unfiltered water, to which one to three drops of standard lead solution (1 c.c. = 1 mgrm. of lead) have been added.

**Erosion.**—This is a more difficult problem. An acid moorland water may be possessed of erosive ability, as well as plumbo-solvent ability; and water possessed of erosive ability has been found, experimentally, sometimes to attack “coated” lead. But in such a case, the quality of plumbo-solvency would, apart from the probably less important question of erosion, suffice to condemn the water. As regards neutral moorland waters, which are possessed of no appreciable solvent action on lead, it may be doubted whether they can, unless exceptionally, erode “coated” lead, since usually they fail under laboratory conditions to erode *bright*

lead. Nevertheless they are commonly so near the possession of erosive ability, under laboratory conditions of experiment, that it would be unwise to deny the possibility of their sometimes overstepping the border line as regards this attribute under natural and exceptional circumstances.

The following procedure should be adopted:—Rinse out three clean test tubes (6 inches by  $\frac{1}{2}$  inch) with the water to be tested. Prepare strips of *bright* sheet lead (1 inch by  $\frac{1}{2}$  inch) in the way described in this volume. (Section I., *see also* Fig. 1, Plate I.) Label the tubes (a), (b), and (c). Pour 10 c.c. of the water to be tested severally into (a) and (b) tubes, and to each add a strip of *bright* lead (1 inch by  $\frac{1}{2}$  inch). Into (c) tube pour 10 c.c. of a mixture in equal proportions of the water to be tested and a distilled water, previously proved to be possessed of erosive ability, and then add a strip of *bright* lead (1 inch by  $\frac{1}{2}$  inch).

The standard suggested is that (a) and (c) tubes should on keeping for at least a week show no signs of erosion; and that the *bright* surface of the lead should become coated with a satisfactory protective adherent film. Further, that as regards (b) tube, the renewal of the lead (*i.e.*, a fresh strip of *bright* lead to replace the old one), on at least two separate occasions (after 24 and 48 hours), should not result in the exhaustion of the “plumbo-protective” substances present in the water, and consequently cause erosion to occur.

No definite opinion can be offered as to the amount of lead which can without danger be present in a water used for domestic purposes. The different susceptibility of different individuals to the influence of lead; the divergent views expressed by different authorities as to what quantity is to be considered a poisonous dose when taken day by day for an indefinite period; and the cumulative character of the poison, are considerations of too grave a nature to allow of any dogmatic statement being made. This aspect of the question was not formulated in the scheme of inquiry, and it was not, therefore, made the subject of special investigation. It will be remembered in this connection that Dr. Whitelegge, who had occasion, while Medical Officer of Health to the West Riding County Council, to study the subject from the scientific, practical, and administrative points of view, expressed the opinion that “no water should be used for drinking which contains more than one part of lead per million, and any trace, however minute, indicates danger.”\*

While it appears that the standards suggested above are convenient as indicating a degree of risk which calls for prompt recognition by public health authorities, and while they will probably obviate danger of any widespread outbreak of plumbism due to water supply, it is not to be contended that in exceptional cases (as where a specially long lead service pipe is concerned, or where individuals are involved possessing special susceptibility to the influence of the poison) the standards in question confer absolute safety. It should be the aim of the authorities controlling moorland supplies to give the consumer water without any demonstrable action on lead, not merely water which barely escapes condemnation by an administrative standard.

In addition to comparison of a given moorland water with the above standards, the examination of the water as it may be supplied to consumers after it has run through lead service pipes for some time, and after it has stood in such pipes for varying periods, should not be neglected. Obviously, however, the use of standard tests such as are suggested is essential if—as is proper—it is desired to secure that the water of a given supply, when it reaches the consumer’s lead pipes, is not capable of acting to any material extent upon them.

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\* Hygiene and Public Health, p. 85. By B. A. Whitelegge, M.D., D.P.H.

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Table CX.—Showing the Effect, as regards Plumbo-solvency, of the Filtration of certain Acid Moorland Waters through Marble.

Table CXI.—Showing the Effect, as regards Plumbo-solvency, of the Filtration of certain Acid Moorland Waters through Chalk.

Table CXII.—Showing the Effect, as regards Plumbo-solvency, of the Filtration of certain Acid Moorland Waters through Flint.

Table CXIII.—Showing the Hardness, Acidity, and Action on Lead of Shipley Water before and after the addition of Powdered Marble, River Sand, Powdered Limestone, Powdered Chalk, Sea Sand, Iceland Spar, and Powdered Flint.

Table CXIV.—Showing the Effect, as regards Acidity and Action on Lead, of treating an Acid Moorland Water with a Neutralising Quantity of Sodium Carbonate ( $\text{Na}_2\text{CO}_3$ ), Lime ( $\text{CaO}$ ), and Chalk ( $\text{CaCO}_3$ ).

Table CXV.—Showing the Effect, as regards Acidity and Plumbo-solvent ability of filtering Shipley Water (an acid Moorland Water) through Limestone.

Table CXVI.—Showing the Amount of the Acidity in Shipley Water (surface of Eldwick Reservoir), and the Effect, as regards Acidity, of preserving the Water for some time—(a) in Completely Filled and Stopped Bottles and (b) in Incompletely Filled and Unstoppered Bottles.

Table CXVII.—Showing the Amount of the Acidity of the Mossley Main Water and the Effect, as regards Acidity, of Preserving the Water—(a) in Completely Filled and Stopped Bottles and (b) in Incompletely Filled and Unstoppered Bottles.

Table CXVIII.—Showing the Amount of the Acidity in Settle Peat Pool Water, and the Effect, as regards Acidity, of keeping the Water for some Time—(a) in Completely Filled and Stopped Bottles and (b) in Incompletely Filled and Unstoppered Bottles.

Table CXIX.—Showing the Results, as regards Acidity, of keeping certain Moorland Waters for varying Periods of Time in Completely Filled and Stopped Bottles and in Bottles only Partially Filled and Unstoppered.

Table CXX.—Showing the Amount of the Acidity in Mossley Main Water, and the Effect, as regards Acidity, of boiling the Water for  $\frac{1}{2}$  hour and making up to the original Amount with a Neutral Distilled Water.

Table CXXI.—Showing the Effect, as regards Acidity—(a) of Boiling and (b) Aeration of Water obtained from "Settle Peat Pool."

Table CXXII.—Showing the Relation between the Amount of the Acidity and Dissolved Oxygen in the Water of "Settle Peat Pool."

Table CXXIII.—Showing the Effect, as regards Acidity, of keeping certain Moorland Waters after Neutralisation with Sodium Carbonate,—(a) in Stopped Bottles with an Air Space; (b) in Unstoppered Bottles; and (c) in Completely Filled and Stopped Bottles.

Table CXXIV.—Showing the Results, as regards Acidity, of the Distillation of certain Acid Moorland Waters.

Table CXXV.—Showing the result of certain Experiments with Peat Ash.

Table CXXVI.—Showing the Result, as regards Acidity, of the addition of Peat Ash to certain Waters.

Table CXXVII.—Showing the Results, as regards Acidity and Plumbosolvency, of certain Experiments with Sulphide of Iron ( $\text{FeS}$ .)

Table CXXVIII.—Showing the Effect of adding Iron Ore to various Waters, and keeping for varying Periods in Stoppered Bottles with Air Space as regards Acidity.

Table CXXIX.—Showing the Effect, as regards Acidity and Action on Lead, of adding Peat (with and without Iron Ore and Peat Iron Ore) to Distilled Water, and keeping the Mixture for varying Periods in Stoppered Bottles with Air Space.

Table CXXX.—Showing the Result, as regards Acidity, of certain Experiments in which Distilled Water and Rain-water were mixed with one of the following substances :—Marcasite ( $\text{FeS}_2$ ) ; Iron Pyrites ( $\text{FeS}_2$ ) ; Sandstone, Shale, and " Bog Iron Ore."

Table CXXXI.—Showing the Results, as regards Acidity and Plumbosolvency, of certain Experiments with Marcasite ( $\text{FeS}_2$ ), Iron Pyrites ( $\text{FeS}_2$ ), Sandstone, and Shale.

Table CXXXII.—Showing the Results of the Chemical Examination of an Acid Water issuing from Coal Workings (rich in Iron Pyrites) on Rochdale Moorland Gathering Grounds.

Table CXXXIII.—Showing the Effect, as regards Acidity and Plumbosolvency, of filtering Water through Rock rich in Iron Pyrites ( $\text{FeS}_2$ ).

Table CXXXIV.—Showing the Effect, as regards Acidity and Plumbosolvency, of leaving Peat in Contact with a large Quantity of Stagnant Water.

Table CXXXV.—Showing the Effect, as regards Acidity and Plumbosolvent Ability, of filtering Distilled Water through Peat. The same Sample of Peat was used throughout the Experiments, but the Filtration was intermittent—the Peat being allowed to rest between each Experiment.

Table CXXXVI.—Showing the Effect, as regards Acidity, of Filtering Boiled Distilled Water (Neutral) through Peat. The same Peat was used throughout, but allowed to rest between each Experiment.

Table CXXXVII.—Showing the Effect, as regards Acidity and Plumbosolvent Ability, of filtering Water intermittently through Peat.

Table CXXXVIII.—Showing the Results, as regards Acidity and Plumbosolvency, of passing Water slowly, but continuously, through Peat saturated with Water.

Table CXXXIX.—Showing the Effect, as regards Acidity and Action on Lead, of adding Peat to Distilled Water and keeping the Mixture for varying Periods in Stoppered Bottle with Air Space.

Table OXL.—Showing the Effect, as regards Acidity and Plumbosolvency, of filtering a Hard Limestone Water through Peat.

Table OXLI.—Showing the Effect, as regards Acidity and Plumbosolvency, of Filtering Non-plumbo-solvent Water through Peat to which certain Substances had been added.

Table OXLII.—Showing, as regards Acidity and Plumbosolvency, the Result of certain Experiments with—(a) Peat containing a large Amount of Iron and (b) Peat containing apparently no Iron.

Table OXLIII.—Showing the Effect, as regards Acidity, of Filtering Distilled Water through—(a) Peat + O and through (b) Peat + " Iron Ore."

Table CXLIV.—Showing the Effect, as regards Acidity and Plumbo-solvency, of heating Peat to 100° C. for some time, and then filtering Distilled Water through it.

Table CXLV.—Showing the Result, as regards Acidity and Plumbo-solvent Ability, of filtering Distilled Water through Peat freshly collected, and through the same Peat after being kept for some considerable time in a moist Chamber.

Table CXLVI.—Showing the Effect of filtering Distilled Water through Peat, as regards the Acidity and Plumbo-solvency of the Filtrate, and also the Result of keeping the Filtrate for varying Periods of Time in—(a) partially Filled and Stoppered Bottle; (b) partially Filled and Stoppered Bottle, but neutralised  $\frac{7}{10}$   $\text{Na}_2\text{CO}_3$ ; (c) completely filled and Stoppered Bottle; (d) completely Filled and Stoppered Bottle, but neutralised  $\frac{7}{10}$   $\text{Na}_2\text{CO}_3$ .

Table CXLVII.—Showing the Result, as regards Acidity, of keeping certain Acid Moorland Waters in Stoppered Bottles, with and without the inhibition of Bacterial Growth with Alcohol.

Table CXLVIII.—Showing the Effect, as regards Acidity, produced by increasing the Nutritive Power of Settle Peat Pool Water with Peat Decoction.

Table CXLIX.—Showing the Result, as regards Acidity, of inoculating Sterile Peat Decoction with Minimal Quantities of Moorland Waters.

Table CL.—Showing the Result, as regards Acidity, of inoculating Sterile Peat Decoction, containing 1 per cent. Glucose with Minimal Quantities of a Moorland Water.

Table CLI.—Showing the Result, as regards Acidity and Plumbo-solvent Ability, of inoculating Sterile Peat Decoction with Minimal Quantities of Certain Moorland Waters.

Table CLII.—Showing the Results of inoculation of Peat Decoction with a Mixture of Peat Micro-organisms.

Table CLIII.—Showing the Result, as regards Acidity, of the inoculation of Sterile Peat Decoction with a mixture of Peat Micro-organisms.

Table CLIV.—Showing the Result, as regards Acidity and Plumbo-solvency, of inoculating Sterile Peat Decoction with a Mixture of Peat Micro-organisms.

Table CLV.—Showing the Results (as regards Acidity) of inoculating Peat Decoction (+ 1 per cent. cane sugar) with a Mixture of Peat Micro-organisms.

Table CLVI.—Showing the Results of inoculation of Sterile Peat Decoction (containing Peptone and Salt) with a Mixture of Peat Micro-organisms.

Table CLVII.—Showing the Result, as regards Acidity, of inoculating Sterile Peat Decoction with a Mixture of Peat Micro-organisms. Cultivated Anaerobically.

Table CLVIII.—Showing the Result of inoculating Peat Decoction (+ 2 per cent. Glucose) with a Mixture of Peat Micro-organisms. Cultivated Anaerobically.

Table CLIX.—Showing the Result (as regards Acidity) of inoculating various Peat Decoctions with Pure Cultivations of Micro-organisms isolated from Peat Soil.

Table CLX.—Showing the Quality of the Water (as regards Acidity and Action on Lead) supplied to various Sanitary Districts in Yorkshire.

## ADDENDUM D.

LIST OF VARIOUS WATERS REFERRED TO IN THE TEXT, IN THE ORDER OF THEIR INCLUSION.

No.

1. *X, XX, XXX Distilled Water.*—See Table III. of this volume.
2. *Settle Water.*—Public water supply to Settle; a hard limestone water.
3. *Mytholmroyd Reservoir Water.*—Survey No. 16, Morley Corporation Waterworks (page 152, Vol. I.).
4. *Withins Stream.*—Ditto.
5. *Jack Clough Stream.*—Ditto.
6. *Fletcher's Dyke Stream.*—Ditto.
7. *Wakefield "Treated" Water.*—Survey No. 23, Wakefield Corporation Works (page 189, Vol. I.).
8. *Wakefield "Untreated" Water.*—Ditto.
9. *Brushes Reservoir Water.*—Survey No. 1, Ashton-under-Lyne Waterworks (page 69, Vol. I.).
10. *Lower Swineshaw Reservoir Water.*—Ditto.
11. *Higher Swineshaw Reservoir Water.*—Ditto.
12. *Yeoman Hey Reservoir Water.*—Ditto.
13. *Watersheddels Reservoir.*—Survey No. 14, Keighley Corporation Waterworks (page 142, Vol. I.).
14. *No. 13, Acid peat feeder to Watersheddels Reservoir.*—Ditto.
15. *Leeds Main Water.*—Survey No. 15, Leeds Corporation Waterworks (page 149, Vol. I.).
16. *Wicken Brook and Spring Waters (Nos. 1, 2, 3, 4, 5).*—See No. 9.
17. *Ferruginous Stream (D 1).*—Survey No. 22, Shipley (Eldwick) Waterworks (page 184, Vol. I.).
18. *Acid Peat Feeder (D 12).*—See No. 17 reference.
19. *Acid Peat Feeder (D 8).*—Ditto.
20. *Acid Peat Feeder (D 2).*—Ditto.
21. *Acid Peat Feeder (D 9).*—Ditto.
22. *Acid Peat Feeder (D 5).*—Ditto.
23. *Weechee Stream.*—Ditto.
24. *Eldwick Reservoir.*—Ditto.
25. *Black Dyke Stream.*—Ditto.
26. *Morley Main Water.*—See No. 3 reference.
27. *No. 13, Acid Feeder.*—See No. 13 reference.
28. *A. Neutral Feeder.*—Ditto.
29. *No. 11, Ferruginous Stream, Neutral.*—Ditto.
30. *No. 10, Acid Feeder.*—Ditto.
31. *Z. Conduit Water, Acid.*—Ditto.
32. *No. 16, Neutral Feeder.*—Ditto.
33. *No. 2, Neutral Feeder.*—Ditto.



- No.
34. *No. 8, Neutral Feeder.*—See No. 13 Reference.
  35. *No. 4, Acid Feeder.*—Ditto.
  36. *No. 3, Acid Feeder.*—Ditto.
  37. *River Don.*—Survey No. 11, Dewsbury and Heckmondwike Water Board (page 127, Vol. I.).
  38. *Great Grain Clough.*—See No. 37 reference.
  39. *Little Grain Clough.*—Ditto.
  40. *Dearden Clough.*—Ditto.
  41. *Swine Clough.*—Ditto.
  42. *Dunford Reservoir Water.*—Ditto.
  43. *Keighley Filtered Water.*—See No. 13 reference.
  44. *Mossley Water* (unless otherwise stated, this indicates *Mossley Main Water*).—See No. 9 reference.
  45. *Sheffield Main Water* (high level).—Survey No. 21, Sheffield Corporation Waterworks (page 178, Vol. I.).
  46. *Sheffield Muin Water* (low level).—Ditto.
  47. *Keighley Water before Filtration.*—See No. 13 reference.
  48. *Bradford Main Water* (high level).—Survey No. 8, Bradford Corporation Waterworks (page 108, Vol. I.).
  49. *Bradford Main Water* (low level).—Ditto.
  50. *Bradfield Water.*—See No. 45 reference.
  51. *Strines Reservoir Water.*—Ditto.
  52. *Ogden Reservoir Water.*—Ditto.
  53. *Hadfield Reservoir Water.*—Ditto.
  54. *Lower Redmires Reservoir Water.*—Ditto.
  55. *Higher Redmires Reservoir Water.*—Ditto.
  56. *Thornton Moor Reservoir Water before Treatment.*—See No. 48 reference.
  57. *Thornton Moor Reservoir Water after Treatment.*—Ditto.
  58. *Moss Spring Water.*—Ditto.
  59. *Stubden Reservoir Water.*—Ditto.
  60. *Yat:holms Reservoir Water.*—Survey No. 5, Batley Corporation Waterworks (page 94, Vol. I.).
  61. *Ramsdeen Clough Water.*—Ditto.
  62. *Yateholme Spring Water.*—Ditto.
  63. *Barnsley Reservoir Unfiltered Water.*—Survey No. 3, Barnsley Corporation Waterworks (page 85, Vol. I.).
  64. *Barnsley Water after Filtration.*—Ditto.
  65. *Shipley Water* (unless otherwise stated, this means *Shipley Eldwich Reservoir Water*).—See No. 17 reference.
  66. *Ringstone Reservoir Water.*—See No. 7 reference.
  67. *Ardley Water (before Treatment).*—Ditto.
  68. *Graincliffe Stream.*—See No. 17 reference.
  69. *Weecher Stream.*—Ditto.
  70. *Watersheddels Reservoir Water* (after passing through Filter Beds).—See No. 13 reference.
  71. *Low Moor Catchwater Conduit.*—See No. 7 reference.
  72. *"Inlet" Water from Sheephouse Reservoir.*—Survey No. 2, Bacup Corporation Works (page 81, Vol. I.).

- No.
73. "*Outlet*" *Water from Sheephouse Reservoir*.—Survey No. 2, Bacup Corporation Works (page 81, Vol. I.).
  74. *Settle Peat Pool Water*.—This water was derived from a pool on the peat on moorland, in the neighbourhood of Settle.
  75. *Morley Water* (unless otherwise stated, this indicates *Morley Main Water*).—See No. 3 reference.
  76. *Cowm Brook Reservoir Water*.—Survey No. 20, Rochdale Corporation Waterworks (page 173, Vol. I.).
  77. *Wham Reservoir Water*.—Ditto.
  78. "*Iron*" *Water from Coal Workings*.—Ditto.
  79. *Feeder (Northside) to Langden Brook*.—Survey No. 19, Preston Corporation Waterworks (page 170, Vol. I.).
  80. *Stony Clough Intake*.—Survey No. 6, Blackburn Corporation Waterworks (page 98, Vol. I.).
  81. *Feeder to Well Spring Clough*.—Ditto.
  82. *Springs Reservoir Water*.—Survey No. 7, Bolton Corporation Waterworks (page 104, Vol. I.).
  83. *Oadshaw Brook*.—Ditto.
  84. *Venemous Clough No. I*.—See No. 70 reference.
  85. *Venemous Clough No. II*.—Ditto.
  86. *Sheephouse Clough Reservoir*.—Ditto.
  87. "*Outlet*" *Blackmoorfoot Reservoir*.—Survey No. 13, Huddersfield Corporation Waterworks (page 138, Vol. I.).
  88. *Poaka Beck Reservoir*.—Survey No. 4, Barrow-in-Furness Corporation Works (page 90, Vol. I.).
  89. *Swinden Brook*.—Survey No. 9, Burnley Corporation Works (page 117, Vol. I.).
  90. *Caut Clough Beck*.—Ditto.
-

**EROSION OF LEAD.****PLATE VII.****FIG. 10.**

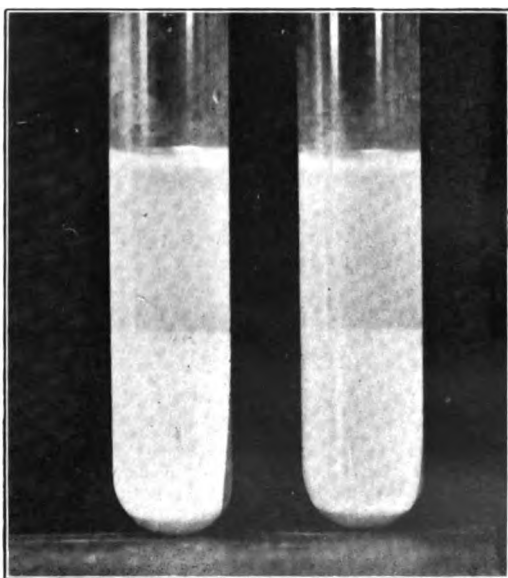
In illustration of Experiment 8 (*a*), (*b*), Table I., showing the erosive action of melted snow-water on *bright* lead. Photographed on the fourth day.

[About natural size.]

**PLATE VII.**

**(a.)**

**(b.)**



**Fig. 10.**





## EROSION OF LEAD.

## PLATE VIII.

FIG. 11.

- |                                                                                  |   |                                                                                                                                                 |
|----------------------------------------------------------------------------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------|
| (a.) Rain-water (August 2, 1894)                                                 | } | To illustrate Experiment 1 (b) and 3 (b), Table I. showing the erosive action of rain-water.                                                    |
| (b.) Rain-water (August 6, 1894).                                                |   |                                                                                                                                                 |
| (c.) Mossley water (August 21, 1894).                                            | } | To illustrate Experiment 2 (a), (b) respectively, Table XXXIX., showing that renewal of the lead leads to erosion in the case of Mossley water. |
| (d.) Mossley water after renewal of the lead twice.                              |   |                                                                                                                                                 |
| (e.) Distilled water X (August 10, 1894).                                        | } | Showing that repeated renewal of the lead leads to erosion in the case of an X distilled water.                                                 |
| (f.) Distilled water X (August 10, 1894), after renewal of the lead seven times. |   |                                                                                                                                                 |

Photographed September 11, 1894.

[About natural size.]

PLATE VIII.

(a.) (b.) (c.) (d.) (e.) (f.)

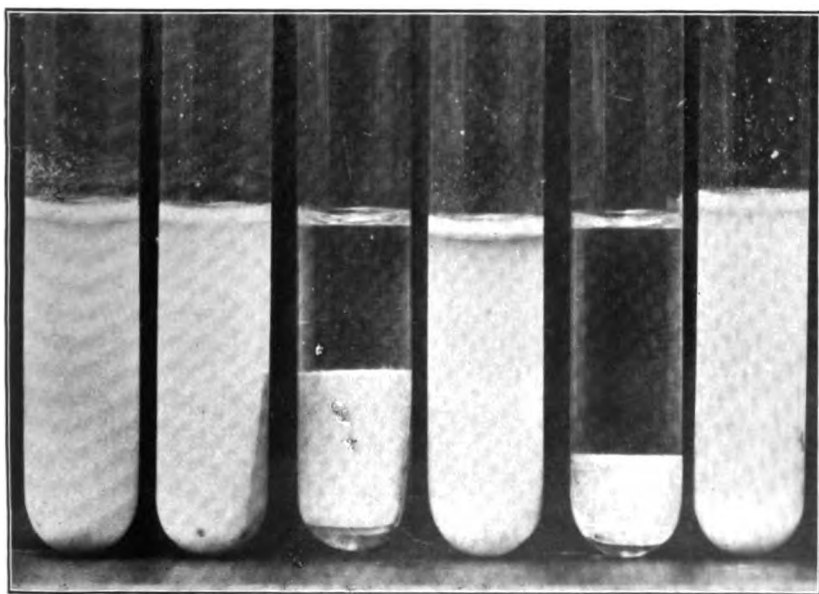


Fig. 11.







# EROSION OF LEAD.

## PLATE IX.

FIG. 12.

Showing (a.) } the non erosive character of X and XX distilled  
 (b.) } water respectively.  
 (c.) the erosive action of XXX distilled water.  
 (d.) the erosive action of XXX distilled water after  
 preliminary treatment as follows :—

After boiling and then allowing water to cool and  
 to re-absorb oxygen from the air.

Photographed 27th day.

[About natural size.]

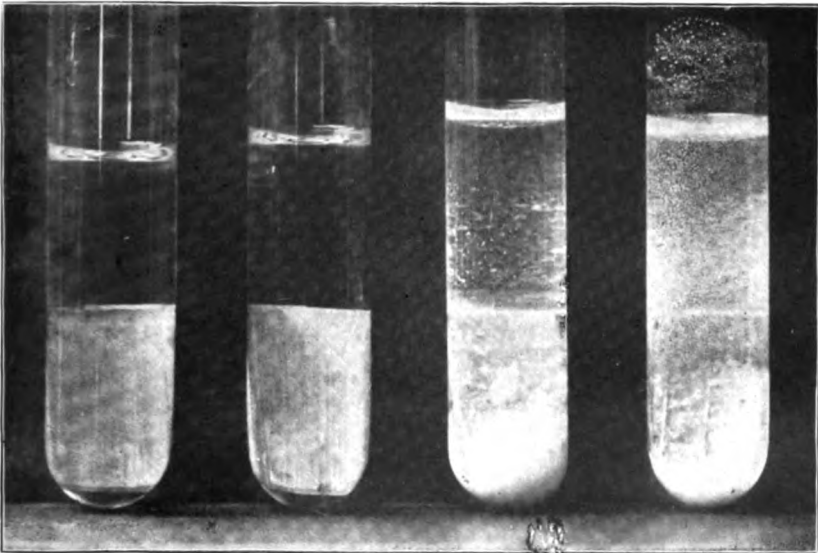
**PLATE IX.**

**(a.)**

**(b.)**

**(c.)**

**(d.)**



**Fig. 12.**





## EROSION OF LEAD.

## PLATE X.

FIG. 13.

- A. 10 c.c. X distilled water. No erosive action.
- B. " " " After exhausting dissolved gases and allowing water to re-absorb oxygen from the air. Decided erosion took place.
- C. " " " After heating to  $100^{\circ}\text{C}$ . for five minutes, allowing water to cool and re-absorb oxygen from the air. Erosion took place.
- D. 10 c.c. XXX distilled water, containing 1 per cent.  $\frac{n}{10}\text{Na}_2\text{CO}_3$ .  
No action took place owing to the inhibitory influence of the sodium carbonate.
- E. " " " , containing 1 per cent.  $\frac{n}{10}\text{H}_2\text{SO}_4$ .  
No action visible when photograph was taken, later, however, erosion commenced.

Photographed fifth day.

[About natural size.]

**PLATE X.**

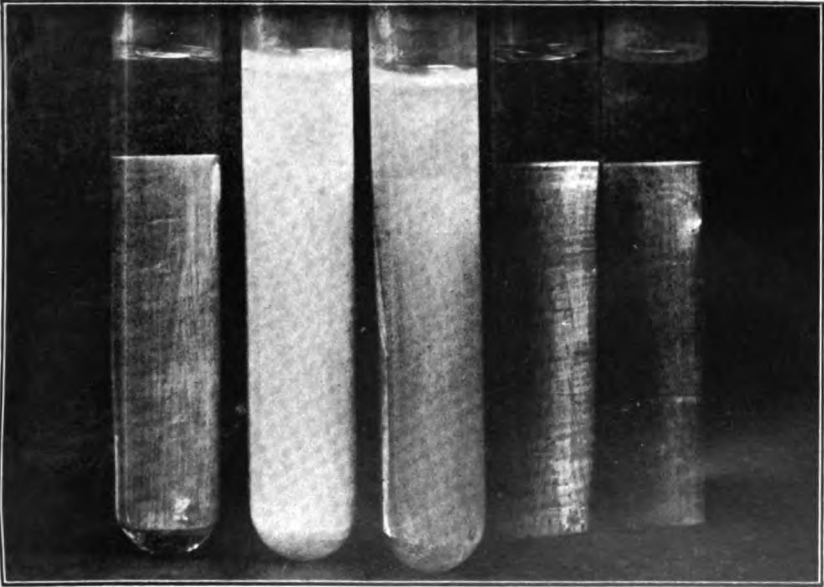
**A.**

**B.**

**C.**

**D.**

**E.**



**Fig. 13.**







## EROSION OF LEAD.

## PLATE XI.

FIG. 14.

In illustration of Table XII. :—

- |                                                 |   |                                                                                                                                                          |
|-------------------------------------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| A. 20 c.c. XXX distilled water<br>in Roux tube. | { | Exhausted of air: no action on lead<br>took place. After a few hours<br>air admitted and then erosion<br>commenced, and was progressive<br>in character. |
| B. 20 c.c. XXX distilled water<br>in Roux tube. | { | Erosion commenced at once, and<br>was progressive in character.                                                                                          |
| C. 20 c.c. XXX distilled water<br>in Roux tube. | { | Exhausted of air and then tube<br>sealed. No action took place.                                                                                          |

Photographed 17th day.

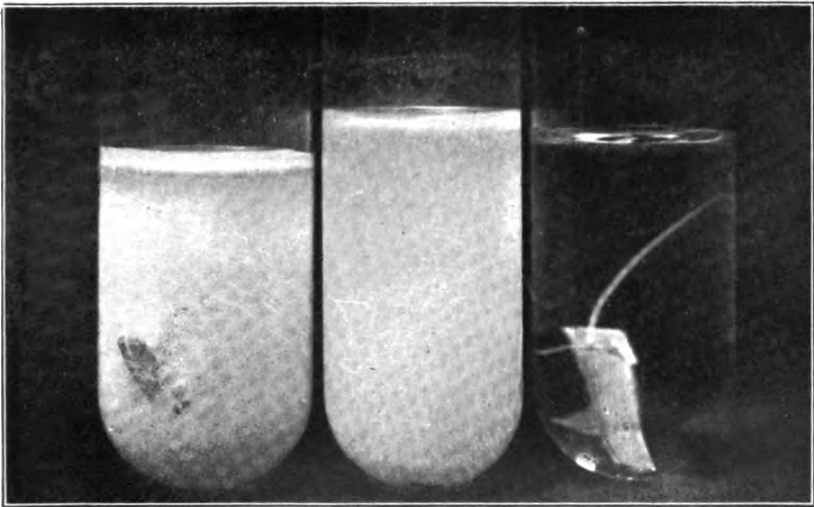
[About natural size.]

**PLATE XI.**

**A.**

**B.**

**C.**



**Fig. 14.**





## EROSION OF LEAD.

## PLATE XII.

FIG. 15.

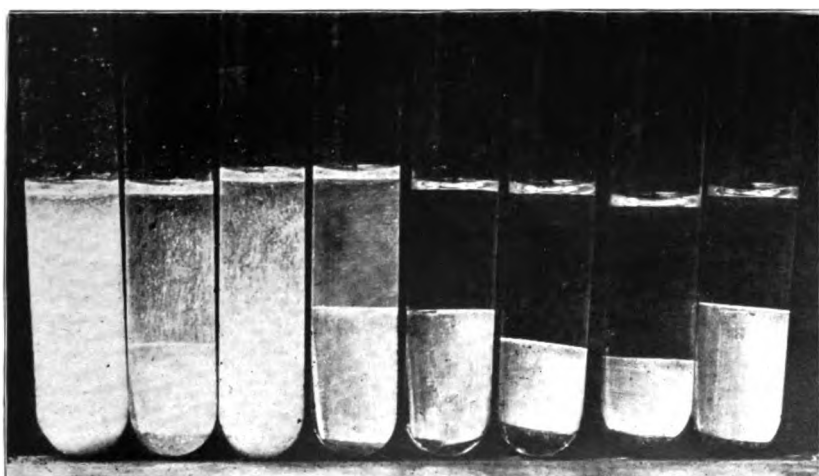
- |                                           |   |                                                                                                                                                                       |
|-------------------------------------------|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (a.) Shipley water of July 5th,<br>1894.  | } | Erosion in all four tubes. In illustration of the erosive ability of a moorland water.                                                                                |
| (b.) Shipley water of July 25th,<br>1894. |   |                                                                                                                                                                       |
| (c.) Shipley water of July 30th,<br>1894. |   |                                                                                                                                                                       |
| (d.) Shipley water of Aug. 6th,<br>1894.  |   |                                                                                                                                                                       |
| (e.) Mossley water of July 6th,<br>1894.  | } | No visible erosion in any of the tubes. Showing that all moorland waters do not erode <i>bright</i> lead although they may be near the possession of erosive ability. |
| (f.) Mossley water of July<br>26th, 1894. |   |                                                                                                                                                                       |
| (g.) Mossley water of July<br>31st, 1894. |   |                                                                                                                                                                       |
| (h.) Mossley water of Aug. 7th,<br>1894.  |   |                                                                                                                                                                       |

Photographed August 11, 1894.

[About natural size.]

**PLATE XII.**

(a.) (b.) (c.) (d.) (e.) (f.) (g.) (h.)



**Fig. 15.**



...

...



## EROSION OF LEAD.

## PLATE XIII.

## FIG. 16.

- Showing (a.) the non-erosive character of X distilled water.  
(b.) the erosive character of X distilled water after preliminary treatment as follows :— Boiling in a platinum dish, and then allowing water to cool and re-absorb oxygen from the air.  
(c.) the erosive character of X distilled water after being kept in a partially filled and unstoppered bottle for some time previous to testing.  
(d.) the erosive character of XXX distilled water.

Photographed 14th day.

[About natural size.]

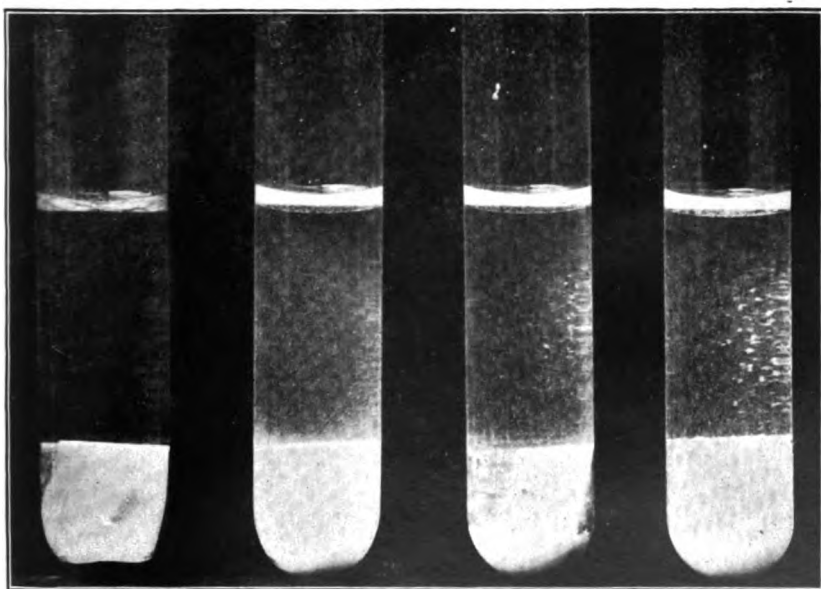
**PLATE XIII.**

**(a.)**

**(b.)**

**(c.)**

**(d.)**



**Fig. 16.**





## EROSION OF LEAD.

## PLATE XIV.

FIG. 17.

- Showing (a.) } the erosive character of X and XXX distilled waters  
 respectively, after preliminary treatment as follows:—Air exhausted and then the waters allowed  
 (b.) } to re-absorb oxygen from the atmosphere.
- (c.) } the erosive character of XXX and X distilled waters  
 respectively, after preliminary treatment as follows:—Washed atmospheric air passed through the  
 (d.) } waters for half an hour.
- (e.) the erosive character of X distilled water after preliminary treatment as follows:—The water was kept for 12 days in a partially filled and un-stoppered bottle.

Photographed 8th day.

[About natural size.]

**PLATE XIV.**

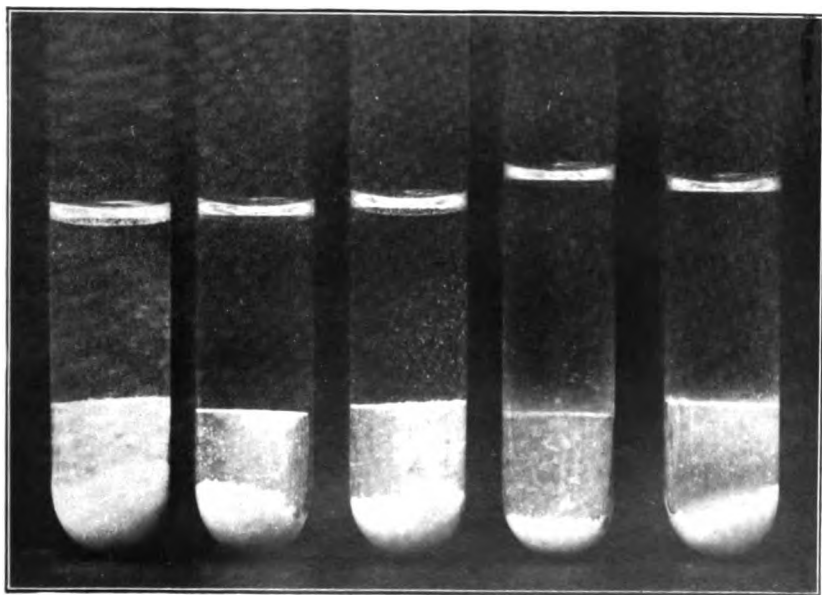
**(a.)**

**(b.)**

**(c.)**

**(d.)**

**(e.)**



**Fig. 17.**







## EROSION OF LEAD.

## PLATE XV.

## FIG. 18.

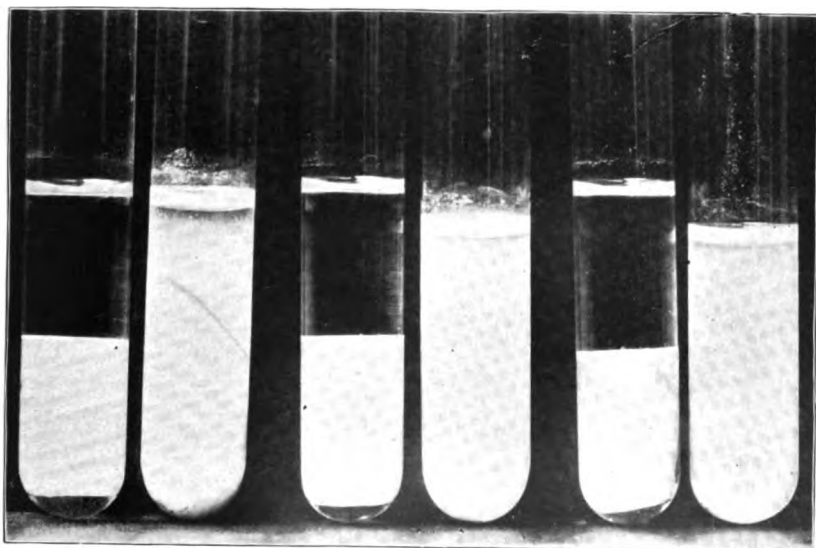
In illustration of Experiment 3 (*e*), (*f*); (*a*), (*b*); (*c*), (*d*), Table XXXVIII., showing that certain moorland waters do not erode *bright* lead (*e*, *a*, and *c*), but are near the possession of erosive ability as may be shown by renewing the lead one or more times (*f*, *b*, and *d*).

Photographed 26th day.

[About natural size.]

**PLATE XV.**

(e.)      (f.)      (a.)      (b.)      (c.)      (d.)



**Fig. 18.**





**EROSION OF LEAD.****PLATE XVI.****FIG. 19.**

**In illustration of Experiment 2, *a*, *b*, Table XXXVIII.**

**Showing (*a'*) that Wakefield "treated" water (sodium carbonate), not only does not erode lead, but is remote from the possession of erosive ability as was proved by frequent renewal of the lead.**

**(*b'*) that Wakefield water before "treatment" erodes lead in vigorous fashion.**

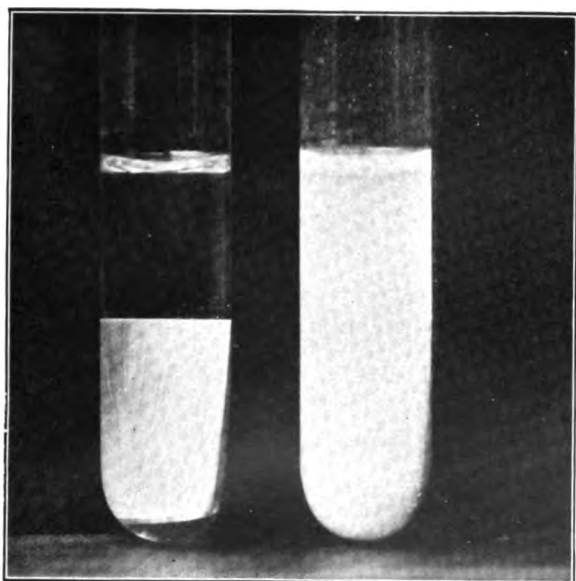
**Photographed 25th day.**

**[About natural size.]**

**PLATE XVI.**

**(a')**

**(b')**



**Fig. 19.**







## EROSION OF LEAD.

## PLATE XVII.

## FIG. 20.

In illustration of Experiments A. and B, Table XLI. Showing the erosive action of Shipley water on *bright* lead after being kept in partially filled and unstoppered bottles for 199 days (A.) and 192 days (B.) respectively.

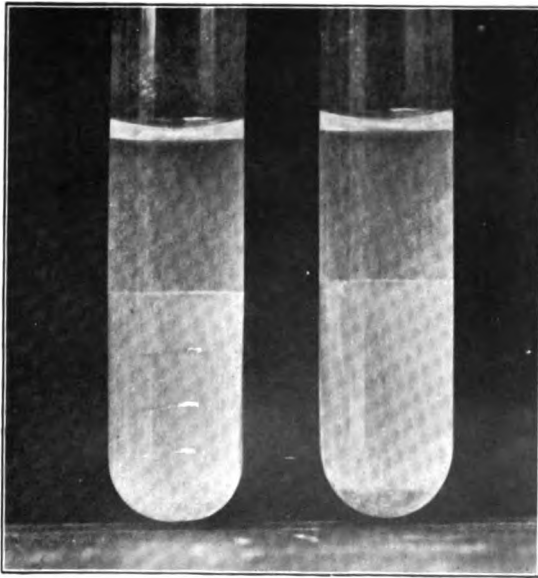
Photographed on the 21st day.

[About natural size.]

**PLATE XVII.**

**A.**

**B.**



**Fig. 20.**

## EROSION OF LEAD.

## PLATE XVIII.

## FIG. 21.

In illustration of Experiment 9, (a), (b), (c), Table LII. Showing the erosive ability of Shipley water on *bright* lead before filtration [(a) tube]; and also after filtration through 25 c.c. sand [(b) tube], and 50 c.c. sand [(c) tube] in the laboratory. It will be noted that erosion has occurred in all three tubes.

Photographed 15th day.

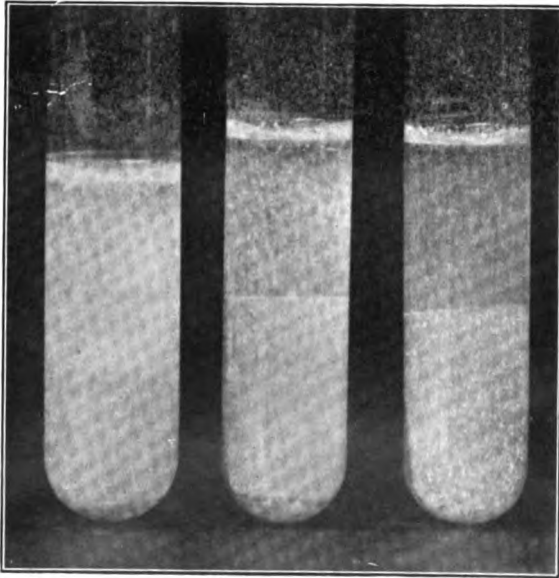
[About natural size.]

**PLATE XVIII.**

**(a.)**

**(b.)**

**(c.)**



**Fig. 21.**













